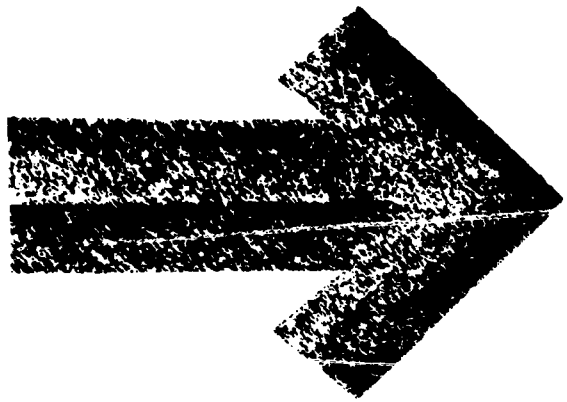
66

63-3-4

404 664



(18) AEC

(19) NP-12594

Report Number

AD No. 404 664
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United States Atomic Energy Commission
Division of Technical Information

CONTENTS

COLOMA EARTHQUAKE

1. EVENT DESCRIPTION

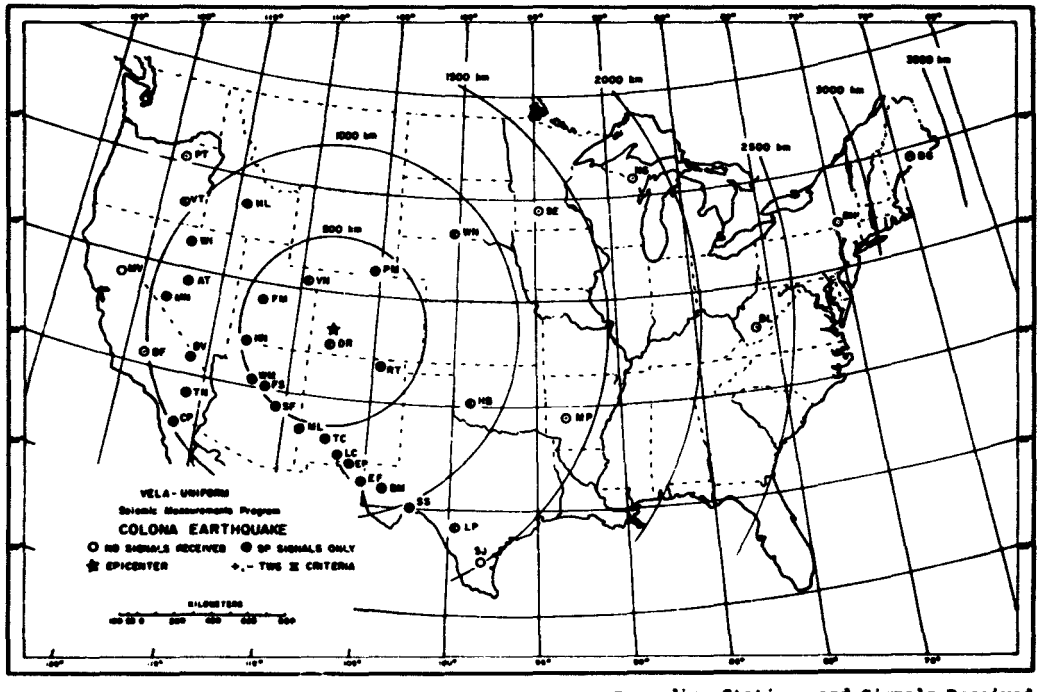
DATE: 5 February 1962

TIME OF ORIGIN: 14:45:51.1Z

DEPTH: about 25 km

GEOGRAPHIC COORDINATES: Lat. 38°12' N
Long. 107°36' W

MAGNITUDE: m = 4.2



Recording Stations and Signals Received

Figure 1

4. Introduction

A long range seismic measurements (LRSM) program was established under VELA-UNIFORM Project 8.4 to record and analyze short-period and long-period seismic data from a planned series of U.S. underground nuclear tests. These, and other data, will be used by VELA-UNIFORM participants for studying and developing methods for distinguishing between explosive and earthquake sources.

The purpose of this report is to provide an analysis of the LRSM film seismograms from 36 mobile field teams for the COLONA EARTHQUAKE of 5 February 1962.

5. Instrumentation

Instrumentation at each of the 36 mobile stations consists of three-component short-period Benioff and three-component Sprengnether long-period seismographs. Shots are recorded on 35 millimeter film and on one-inch 14 channel magnetic tape. All of these stations are equipped to record WWV continuously in order to provide accurate time control. Calibration is accomplished once each day and just prior to each shot at operating settings. Specific details of the instrumentation and operating procedures for these stations are given in "Routine Operating Instructions," which may be obtained from AFTAC or from the Geotechnical Corporation, Dallas, Texas.

Station site information is presented in Appendix I. This includes the station name and code; the geographic coordinates, distances and azimuths involved; the station elevations; and the type of instruments in use at each location.

Figure 1 identifies each operational station, and indicates which instruments were recording usable signals.

An explanation of the procedure for amplitude measurements used in this report is illustrated in Appendix II. The unified magnitude (m) computations for distances less than 16° are based on AFTAC extensions of Gutenberg's tables.*

Appendix III quotes the Technical Working Group II (TWG-II) first motion criteria, and includes diagrams illustrating the elements involved in determining a compression or rarefaction where satisfactory measurements can be made.

*Gutenberg, B. and Richter, C.F., Magnitude and Energy of Earthquakes, Ann. Geofis., 9 (1956), pp. 1-15.

6. Data and Results

Table 1 summarizes the measurements made of the principal phases of the COLONA EARTHQUAKE. Included are the P_n and P arrival times, the maximum amplitudes (A/T) of the P_n or P and P_g motion seen on the short-period vertical instruments, and the maximum amplitudes (A/T) of the L_g phase as measured on both horizontal seismometers. These seismometers are oriented for radial and tangential measurements from NTS. Short-period signals from this event were recorded by 27 stations. No stations recorded long-period phases.

Also shown in Table 1 are unified magnitudes (m) where measurable. First motion criteria (TWG-II) was not applicable for this event. The unified magnitudes are shown graphically in Figure 2.

The travel-time residuals from P_n or P phases are shown in Figure 3. The amplitudes of P_n or P, P_g, L_g radial and L_g transverse are shown in Figures 4, 5, 6 and 7. Lines proportional + the inverse cube of the distance visually fitted through the observed points are shown on the graphs. Higher frequency signals were observed from the COLONA EARTHQUAKE than from most nuclear explosions; and the rate of attenuation of these higher frequency signals appears greater than that of the inverse cube of distance associated with nuclear explosions.

Attached to the report are illustrative seismograms showing the signals recorded at a number of locations. Included also are seismograms showing short-period Z, R, T, R' and T'. R' and T' have been rotated for correct orientation with reference to the epicenter and show true radial and transverse motion.

Code	Station	Distance (km)	Inst	Magnification (h) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	Magnitude (m)	Record Attached
BR CO	Durango, Colorado	81	BPZ	192	e Pg	00	15.6	---	---		a
			BPR	392	Lg			---	---		
			BRT	372	Lg			---	---		
VR UT	Vernal, Utah	308	BPZ	159	e Pn	00	42.6	0.4	9.26	3.8	
			BPE	159	Pg			---	---		
			BPR	165	Lg			---	---		
			BRT	201	Lg			---	---		
RT NM	Raton, New Mexico	330	BPZ	122	e Pn	00	(50.3)	NOT USEABLE			
			BPE	122	Pg	00	(52.9)	-	-		
			BPR	150	Lg			-	-		
			BRT	155	Lg	01	33.5	0.3	17 7		
PM WY	Pole Mountain, Wyoming	385	BPZ	142	e Pn	00	53 6	0.35	13 4	4.0	b
			BPE	142	Pg	01	00 5	0 4	97 7		
			BPR	130	Lg	01	41.9	---	---		
			BRT	85.5	Lg	01	42.2	---	---		
FH UT	Fillmore, Utah	416	BPZ	276	e Pn	00	57.6	0.45	11.9	4.1	a
			BPE	276	Pg	01	(03 6)	2.45	186		
			BPR	308	Lg			---	---		
			BRT	266	Lg			---	---		
KB UT	Kanab, Utah	480	BPZ	312	e Pn	01	05.8	0.6	7.11	4.1	
			BPE	312	Pg			---	---		
			BPR	352	Lg			---	---		
			BRT	308	Lg			---	---		
FS AZ	Flagstaff, Arizona	480	BPZ	250	e Pn	01	06.3	0.6	3.62	3 7	b
			BPE	250	Pg	01	(10 7)	0.45	199		
			BPR	256	Lg			---	---		
			BRT	268	Lg			---	---		
SF AZ	Snowflake, Arizona	493	BPZ	235	e Pn	01	07 8	(0.4)	(7.16)	4.1	
			BPE	235	Pg	01	17 6	0.4	110		
			BPR	230	Lg			0.4	206		
			BRT	278	Lg	02	(38 6)	0.6	170		
WM AZ	Williams, Arizona	515	BPZ	308	e Pn	01	11.9	0.6	25.5	4.7	
			BPE	308	Pg	01	21.6	0.55	195		
			BPR	431	Lg			0.35	(362)		
			BRT	441	Lg			0 3	(296)		
ML NM	Magdalen, New Mexico	547	BPZ	212	e Pn	01	(16.1)	0.4	1.79	3.7	
			BPE	212	Pg	01	27.0	0.5	42 7		
			BPR	216	Lg	02	(29 5)	0.5	23 5		
			BRT	218	Lg			0.6	(38.6)		
TC NM	Truth or Consequences, New Mexico	557	BPZ	136	e Pn	-	-	-	-		
			BPE	136	Pg	01	32 5	(0.3)	(107)		
			BPR	168	Lg			0.45	246		
			BRT	150	Lg	02	38.5	0.4	151		
LC NM	Las Cruces, New Mexico	650	BPZ	392	e Pn	-	-	-	-		a
			BPE	392	Pg	01	47.0	0.55	8.86		
			BPR	392	Lg			0.5	15.1		
			BRT	392	Lg			0.8	10.8		
EP TX	El Paso, Texas	711	BPZ	284	e Pn	-	-	-	-		
			BPE	284	Pg			0.5	6.76		
			BPR	296	Lg			-	-		
			BRT	336	Lg			NOT USEABLE			
DV CL	Death Valley, California	841	BPZ	343	e Pn	-	-	-	-		
			BPE	343	Pg	02	09.9	0.6	14.1		
			BPR	284	Lg			0.9	27.4		
			BRT	261	Lg	03	39.3	0.85	41.0		

A/T mμ/sec
e Emergent Start
a Station Seismograms to be included in Nevada Test Site report when possible

--- No signal
--- Signal not measurable because of excessive amplitude or amplifier clipping
( ) Doubtful values or phases
b Station seismograms to be included as desirable.

Principal Phases - COLOMA EARTHQUAKE

Table 1

Code	Station	Distance (km)	Instr.	Magnification (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	Signal-Code (sq)	Record Attached
EP TE	Eagle Flat. Texas	811	SP	300	P	-	-	-	-		
			SP	300	P?	02	(14.6)	0.65	9.17		
			SP	630	LR	02	(45.7)	0.6	9.53		
			SP	630	Lg	02	(48.6)	0.6	6.34		
EL ID	Bailey. Idaho	825	SP	350	P	01	48.3	0.5	1.51	6.1	b
			SP	350	P?	02	16.3	0.6	6.18		
			SP	341	LR			0.7	10.8		
			SP	341	Lg			0.55	13.2		
AT NV	Austin. Nevada	835	SP	330	P	01	50.7	(0.6)	(2.88)	6.2	
			SP	330	P?	02	16.7	0.75	10.0		
			SP	317	LR			0.8	11.9		
			SP	323	Lg	03	486	0.85	12.7		
WB SD	Wasson. South Dakota	840	SP	55.5	P	01	(50.1)	ENV NOISE/LE			
			SP	55.5	P?	02	(14.3)	0.6	51.5		
			SP	52.5	LR			0.55	152		
			SP	44.4	Lg	03	(48.6)	0.6	176		
EB OK	Hobart. Oklahoma	866	SP	79.5	P	01	(55.0)	(0.6)	(12.9)	5.0	
			SP	79.5	P?	02	21.9	(0.6)	(32.2)		
			SP	99.0	LR	03	99	0.7	81.5		
			SP	101	Lg	03	30.5	0.7	73.2		
TP CL	Twenty Nine Palms. California	872	SP	252	P	01	(55.6)	ENV NOISE/LE			
			SP	252	P?	02	(26.9)	0.65	0.61		
			SP	260	LR	06	(86.1)	0.75	16.7		
			SP	238	Lg			0.75	25.6		
EB TE	Balmorhea. Texas	877	SP	300	P	-	-	-	-		
			SP	300	P?	02	38.5	0.6	4.99		
			SP	270	LR			0.6	6.01		
			SP	360	Lg	04	63.2	0.75	8.58		
WI NV	Winnemucca. Nevada	916	SP	667	P	-	-	-	-		a
			SP	667	P?	02	29.9	0.5	10.9		
			SP	355	LR	06	(88.9)	0.7	13.8		
			SP	373	Lg			0.65	15.8		
AD NV	Alan Nevada	923	SP	557	P	02	88.9	0.6	2.15	4.6	a
			SP	557	P?	02	29.9	0.7	6.77		
			SP	506	LR	06	23.9	0.8	5.67		
			SP	564	Lg	06	23.4	0.5	5.89		
CP CL	Campo California	1000	SP	203	P	02	(13.7)	ENV NOISE/LE			
			SP	203	P?			-	-		
			SP	345	LR			(0.8)	(2.77)		
			SP	316	Lg			ENV NOISE/LE			
SB TE	Sanderson Texas	1029	SP	681	P	-	-	-	-		
			SP	681	P?	02	(51.3)	0.65	5.09		
			SP	612	LR			(0.8)	(15.1)		
			SP	630	Lg	06	(66.6)	(0.9)	(19.2)		
VT GD	Venator Oregon	1066	SP	363	P	-	-	-	-		
			SP	363	P?			0.5	5.09		
			SP	288	LR			0.7	16.9		
			SP	296	Lg			0.7	13.7		
LP TE	La Pryor. Texas	1240	SP	611	P	-	-	-	-		
			SP	611	P?			0.8	5.01		
			SP	616	LR			0.8	7.51		
			SP	660	Lg			0.8	9.98		

A/T = Up/Dec
e = Emergent Start
* = Station Seismogram to be Included in Nevada Test Site report when possible

- = No signal
--- = Signal not measurable because of excessive amplitude or amplifier clipping
( ) = Doubtful values or phases
b = Station seismogram to be included as desirable.

Principal Phases - COLOMA EARTHQUAKE

Table 1 (Continued)

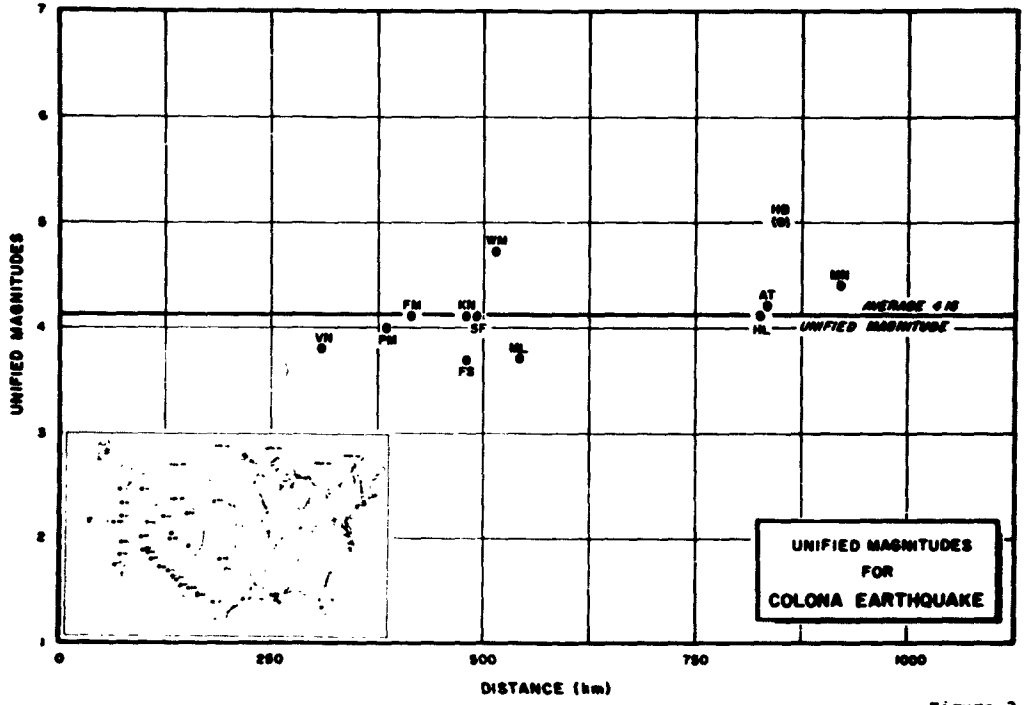

UNIFIED MAGNITUDES
DISTANCE (km)
0
250
500
750
1000
1
2
3
4
5
6
7
HB
WM
MB
AT
FM
KN
SF
VN
PM
FB
ML
HL
AVERAGE 4.16
UNIFIED MAGNITUDE
UNIFIED MAGNITUDES
FOR
COLONA EARTHQUAKE

Figure 2

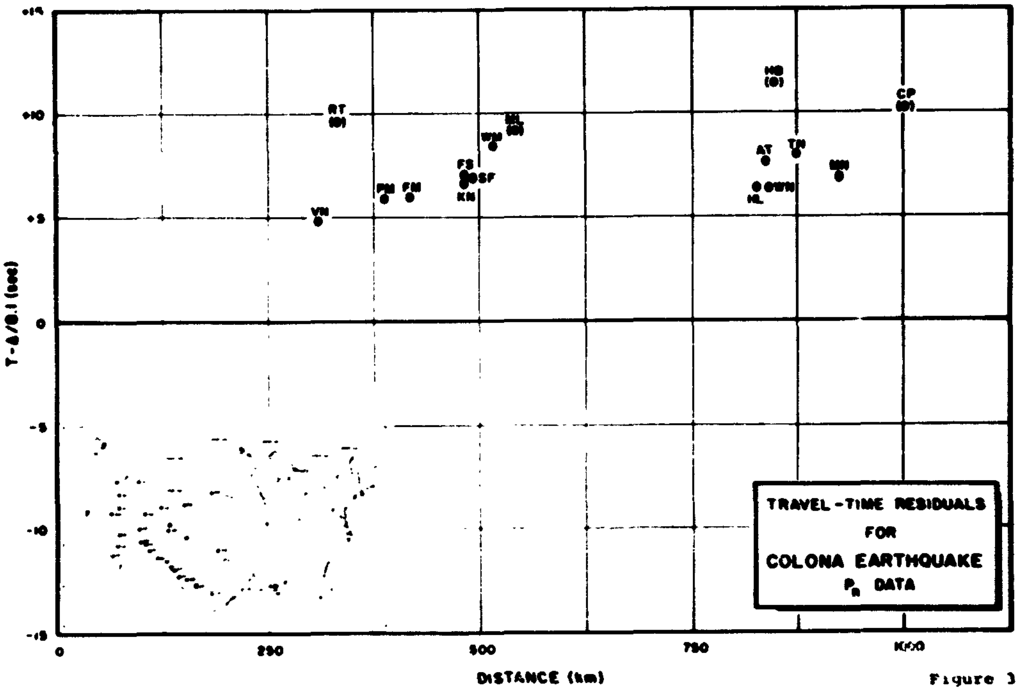

TRAVEL-TIME RESIDUALS
FOR
COLONA EARTHQUAKE
P_n DATA
DISTANCE (km)
T-Δ/8.1 (sec)
+15
+10
+5
0
-5
-10
-15
0
250
500
750
1000
RT (D)
VN
PM
FM
FS
SF
KN
WM
ML (D)
HB (D)
AT
TN
HL
OWN
MN
CP (D)

Figure 3

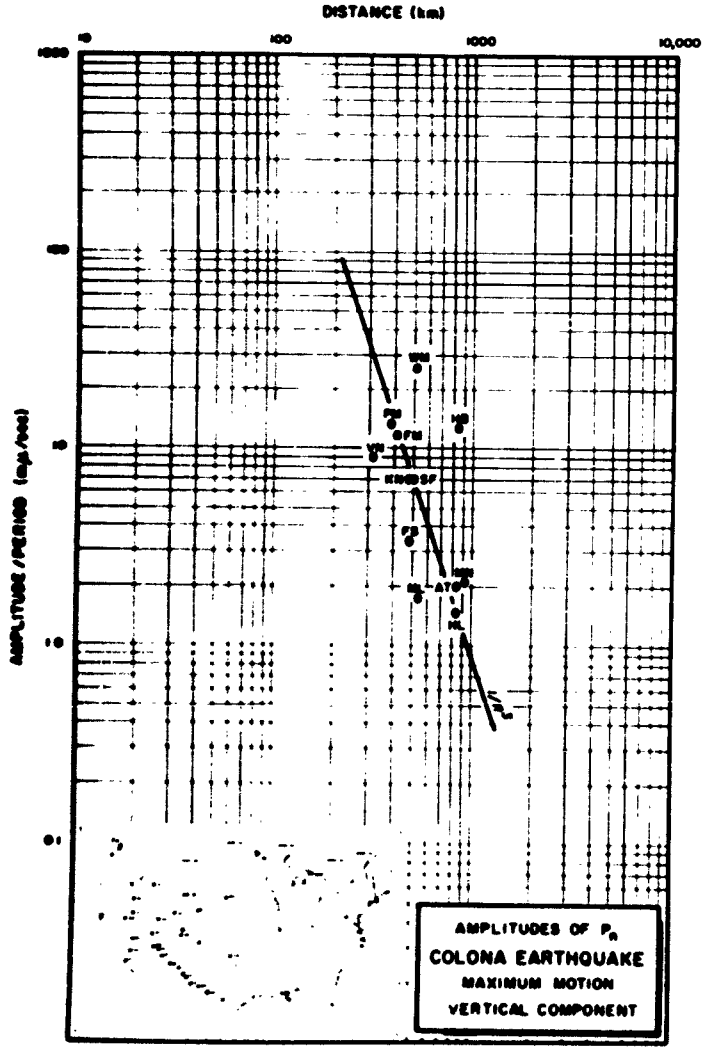


Figure 4

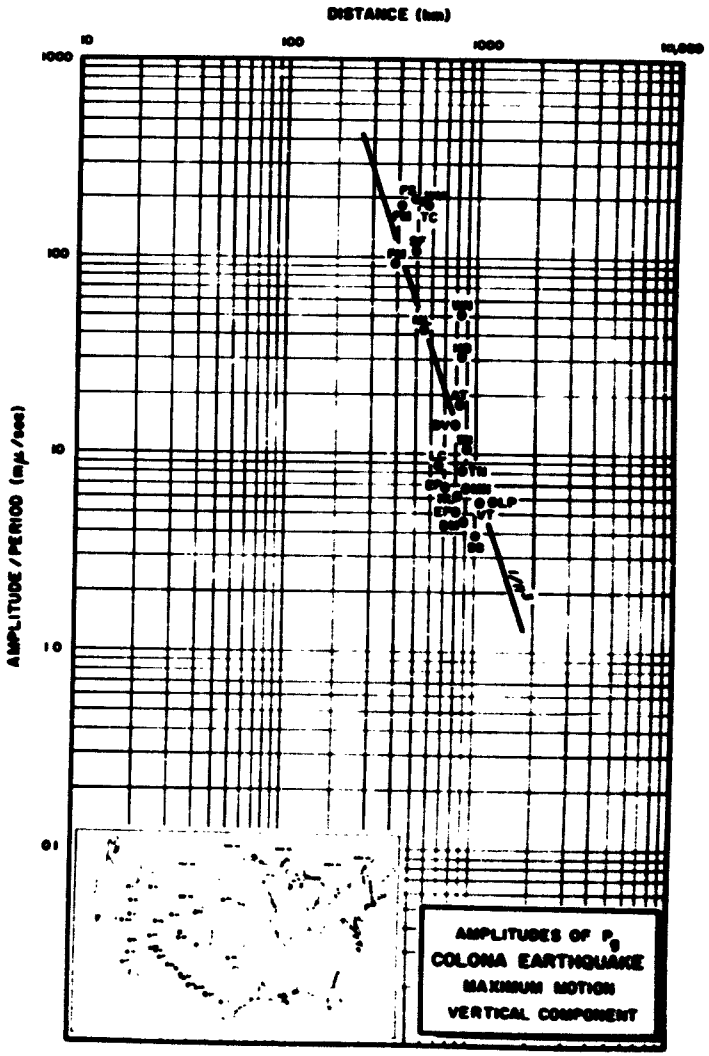


Figure 5

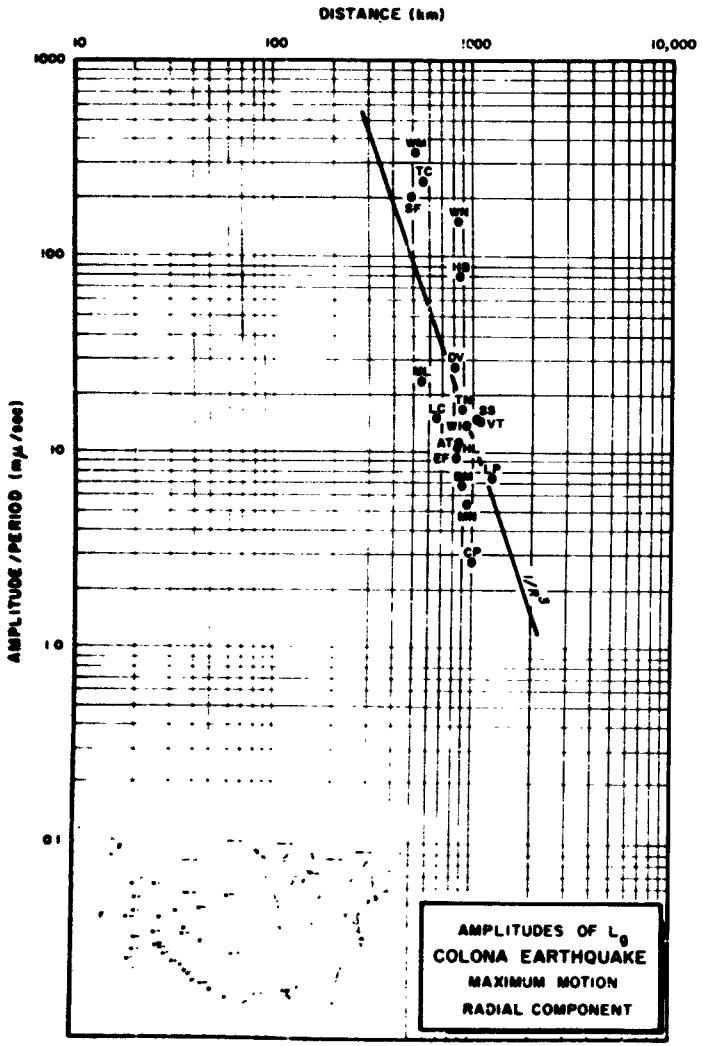


Figure 6

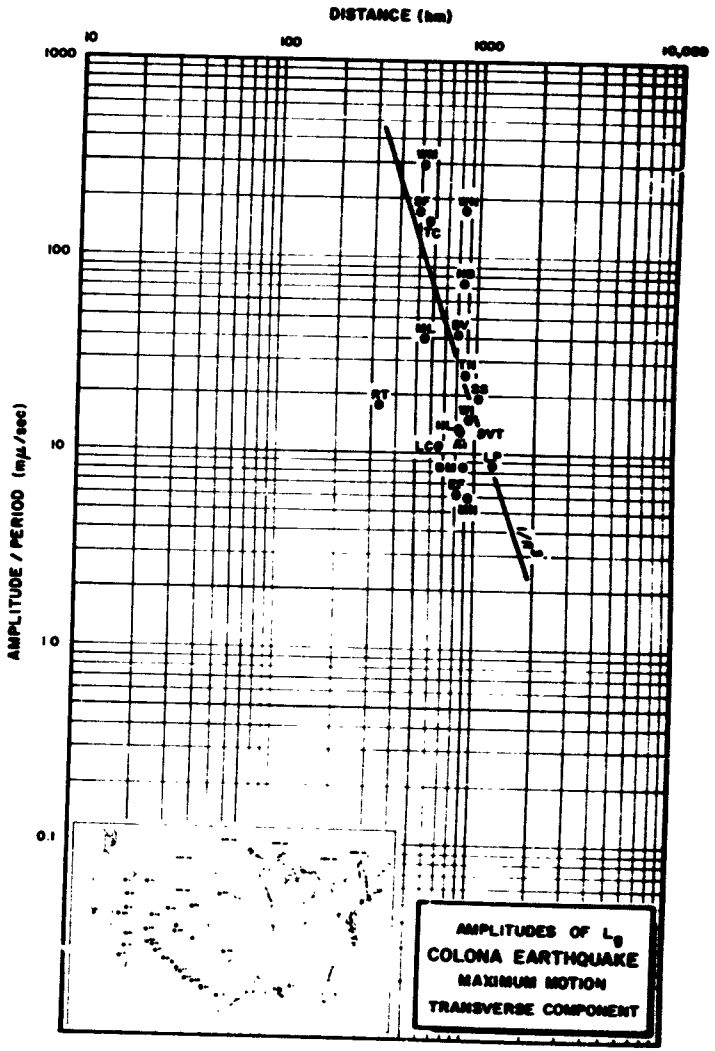


Figure 7

ERRATA

Recording Site Information Changes:

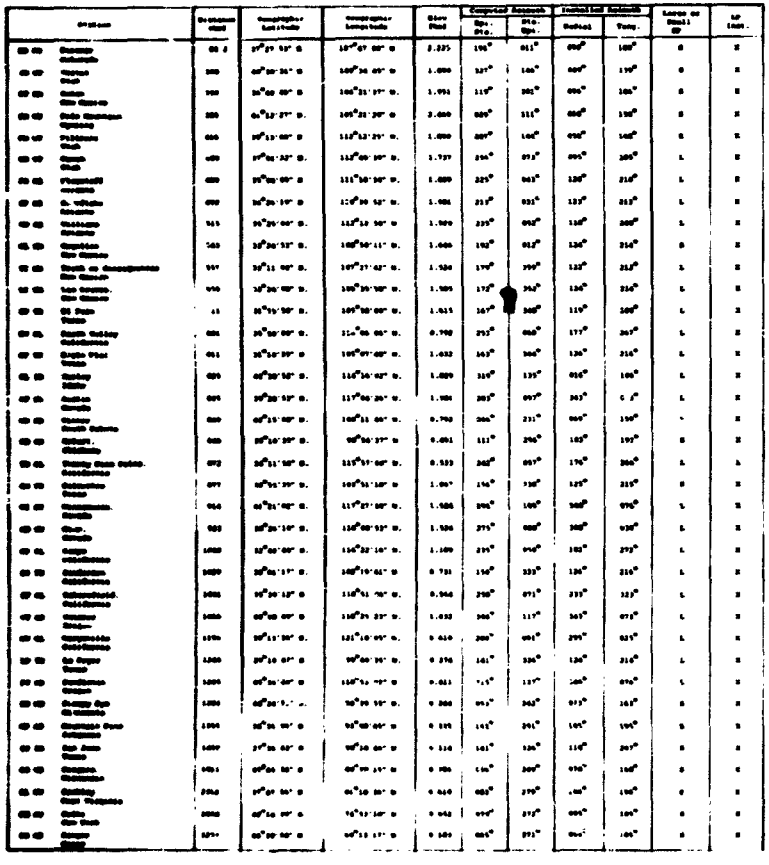
MV CL - Geographical Latitude -

39° 12' 47" N

MV CL - Geographical Longitude -

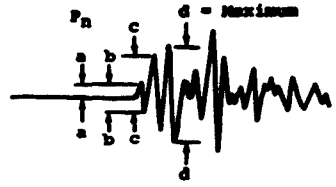
121° 17' 35" W

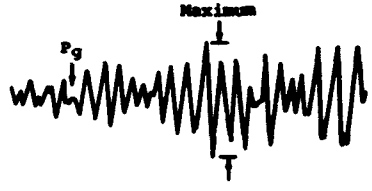
Elevation: .183 Km

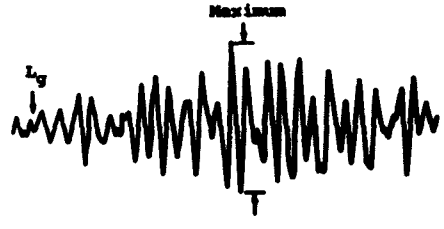


Recording Site Information - COLOMBIA EARTHQUAKE

Appendix I







Detail Showing Allowance For Line Width

Pick time of Pn at beginning of "a" half cycle.

Pick amplitude of Pn as maximum "$d/2$" within 2 or 3 cycles of "c".

Pick amplitudes of Pg and Lg at maximum of corresponding motion.

Seismic Analysis Diagram

Appendix II

FIRST MOTION CRITERIA
TECHNICAL WORKING GROUP II (TWG II)

Excerpt from Appendices to Hearings before the Special Subcommittee on Radiation and the Subcommittee on Research and Development of the Joint Committee on Atomic Energy; 86th Cong., 2d Sess.; April 19-22, 1960; on Technical Aspects of Detection and Inspection Controls of a Nuclear Weapons Test Ban; Part 2 of 2 Parts, pp 632-633:

"2. Identification of Earthquakes

A located seismic event shall be ineligible for inspection if, and only if, it fulfills one or more of the following criteria:

a. Its depth of focus is established as below 60 kilometers;

b. Its epicentral location is established to be in the deep open ocean and the event is unaccompanied by a hydroacoustic signal consistent with the seismic epicenter and origin time;

c. It is established within 48 hours to be a foreshock by the occurrence of a larger event of at least magnitude 6 whose epicenter coincides with that of the given event within the accuracy of the determination of the two epicenters. The eligibility of the second event for inspection must be determined separately.

d. The directions of clearly recorded first motions define a pattern which strongly indicates a faulting source. First motions recorded at distances between 1100 kilometers and 2500 kilometers will not be used. First motions beyond 3500 kilometers will not be used for events of magnitude smaller than 5.5. The apparent direction of first motion must also meet both the following minimum conditions to be considered to be clearly recorded:

(1) The amplitude of the half-cycle of apparent first motion is at least two (2) times as large as any half-cycle of apparent noise in the preceding few minutes, and

(2) The largest of the amplitudes of the half-cycle of apparent first motion and the two immediately following half-cycles:

(a) at epicentral distances less than 700 kilometers is twenty (20) times larger than any half-cycle of noise in the preceding few minutes;

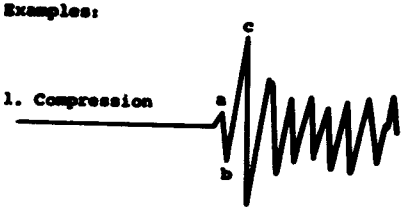
(b) at epicentral distances more than 700 kilometers is forty (40) times larger than any half-cycle of noise in the preceding few minutes.

A pattern of clearly recorded first motions strongly indicates a faulting source if the observed motions, extended backward to a small sphere about the focus, can be separated into alternate quadrants by two orthogonal great circles drawn on the small sphere, with the requirement that two opposite quadrants combined (i) contain at least 6 clearly recorded rarefactive first motions and (ii) contain not more than 15% compressions among the clearly recorded first motions."

Application of the TWG II Criteria

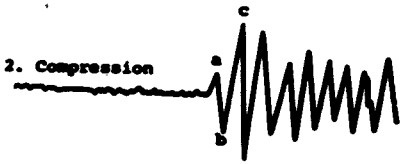
Examples:

1. Compression



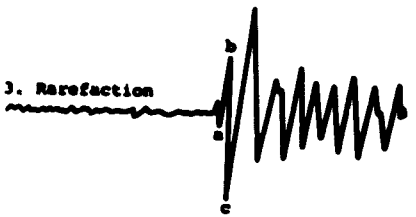
700 < Δ < 1100 Km

2. Compression



Δ < 700 Km

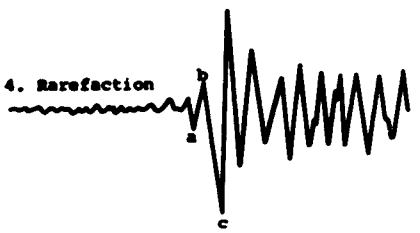
3. Rarefaction



Δ < 700 Km. Example shows what may be interpreted to be earlier signal; however, motion is less than 2 times the noise level and may be interpreted as noise.

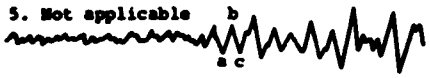
Application of the TWG II Criteria

4. Rarefaction

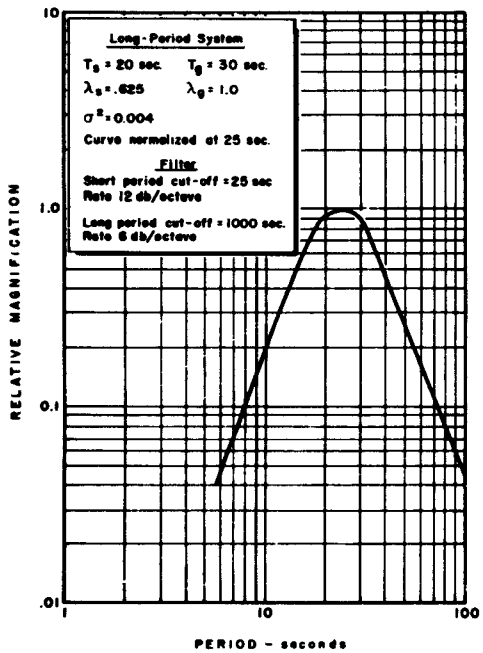


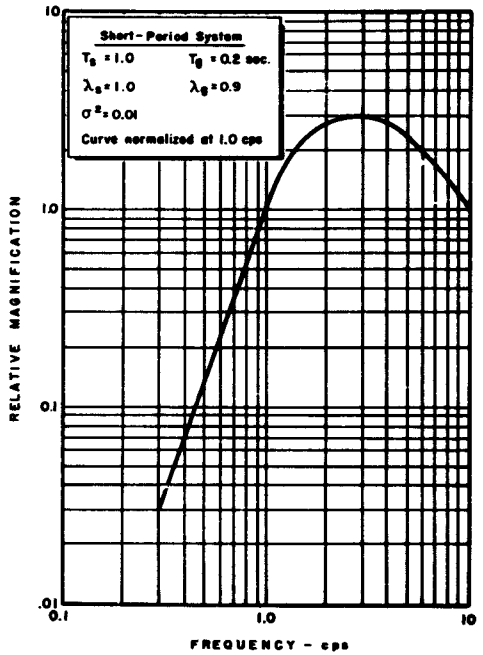
Δ < 700 Km
Similar to Example 3.

5. Not applicable



Δ < 700 Km
Amplitude of first 3 half-cycles is less than 20 times noise.





LP and S[illegible] Response Curves

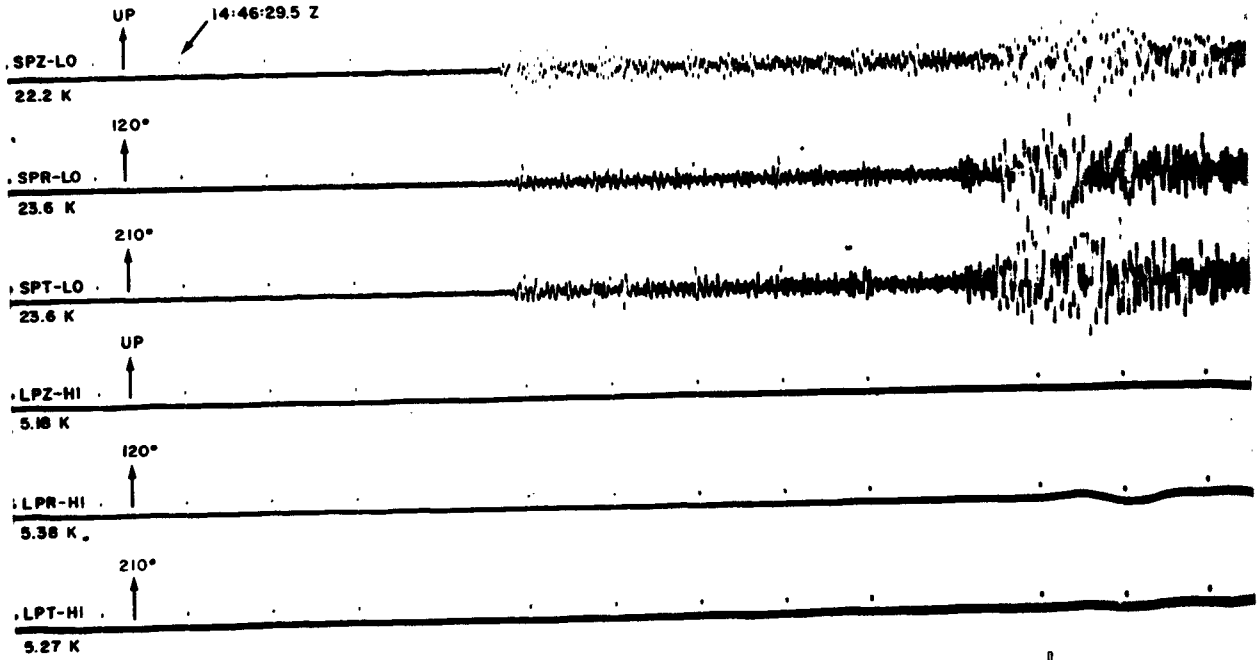
COLONA EARTHQUAKE

FS AZ

Flagstaff, Arizona

5 February 1962

Δ= 480 km



Reoriented Horizontal Components

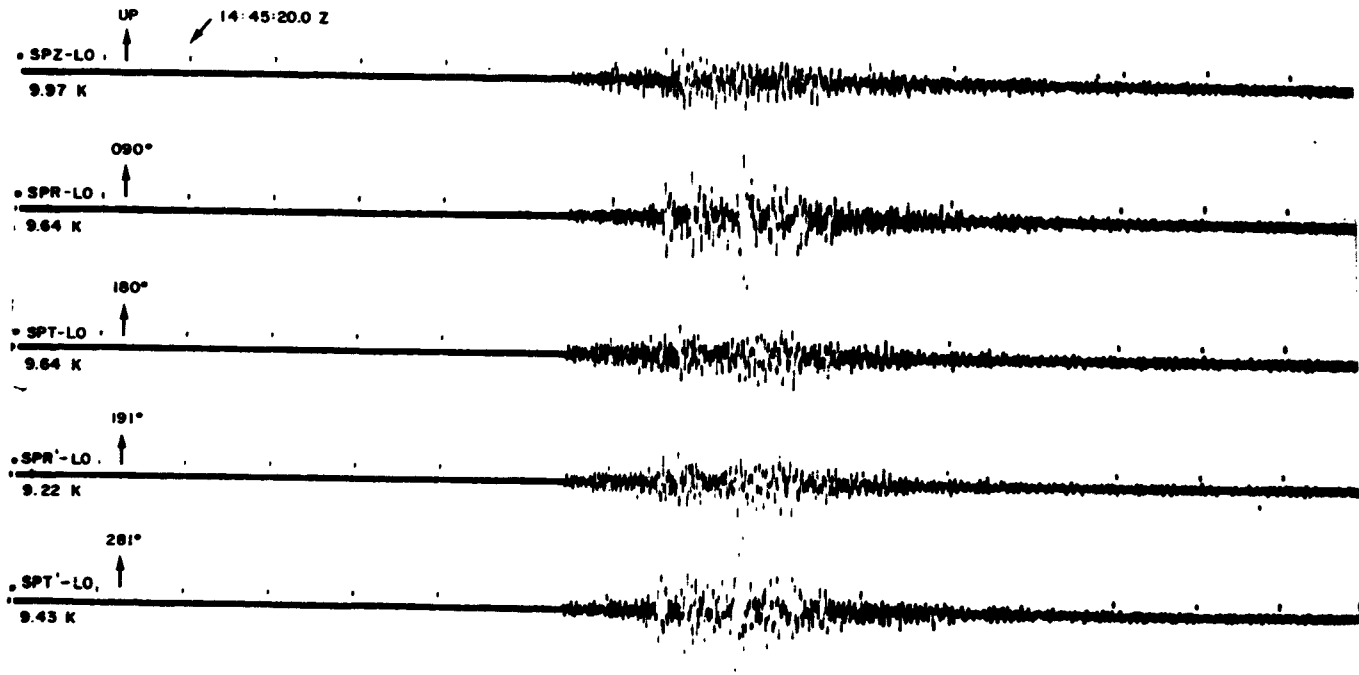
COLONA EARTHQUAKE

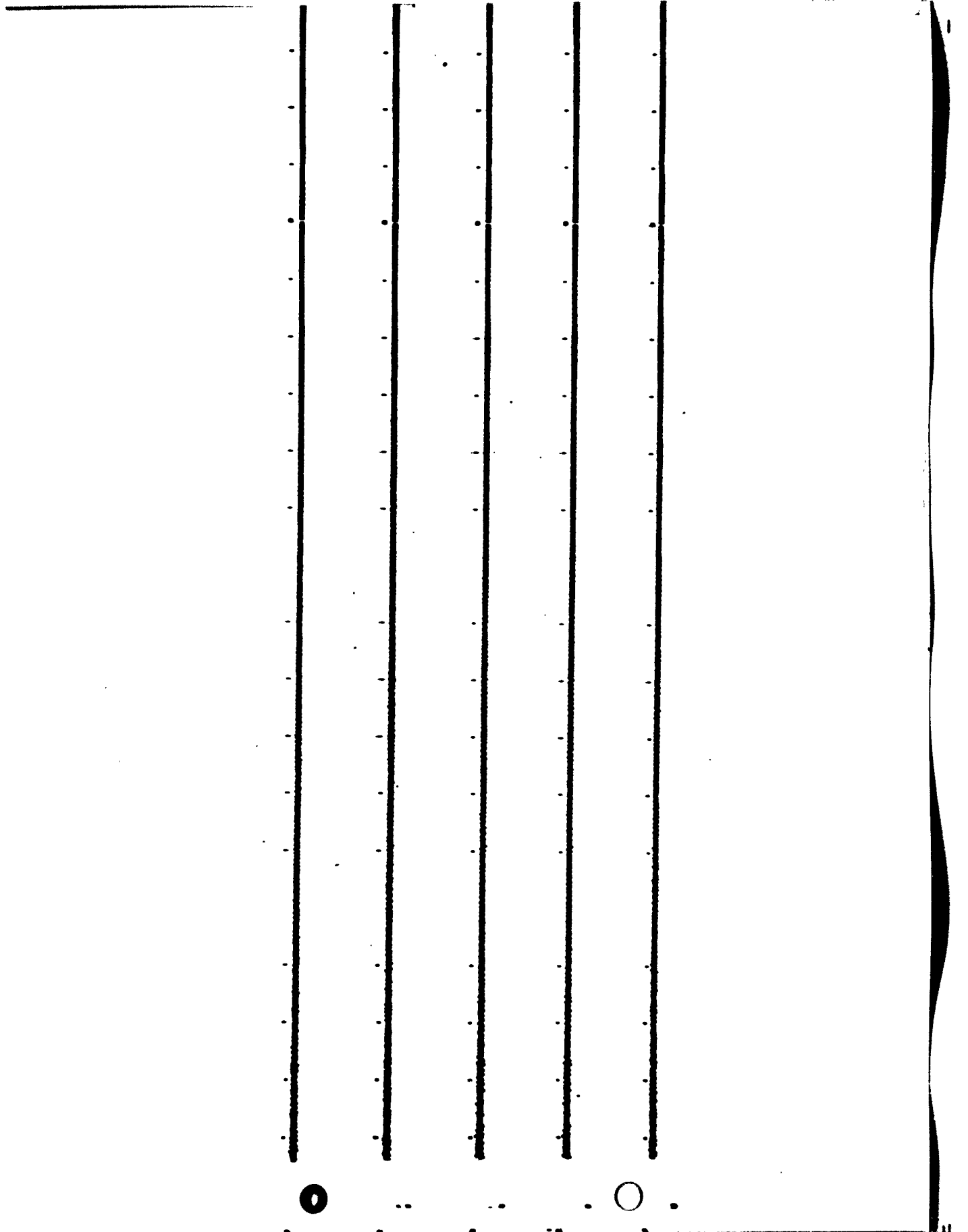
DR CO

Durango, Colorado

5 February 1962

Δ = 83 km





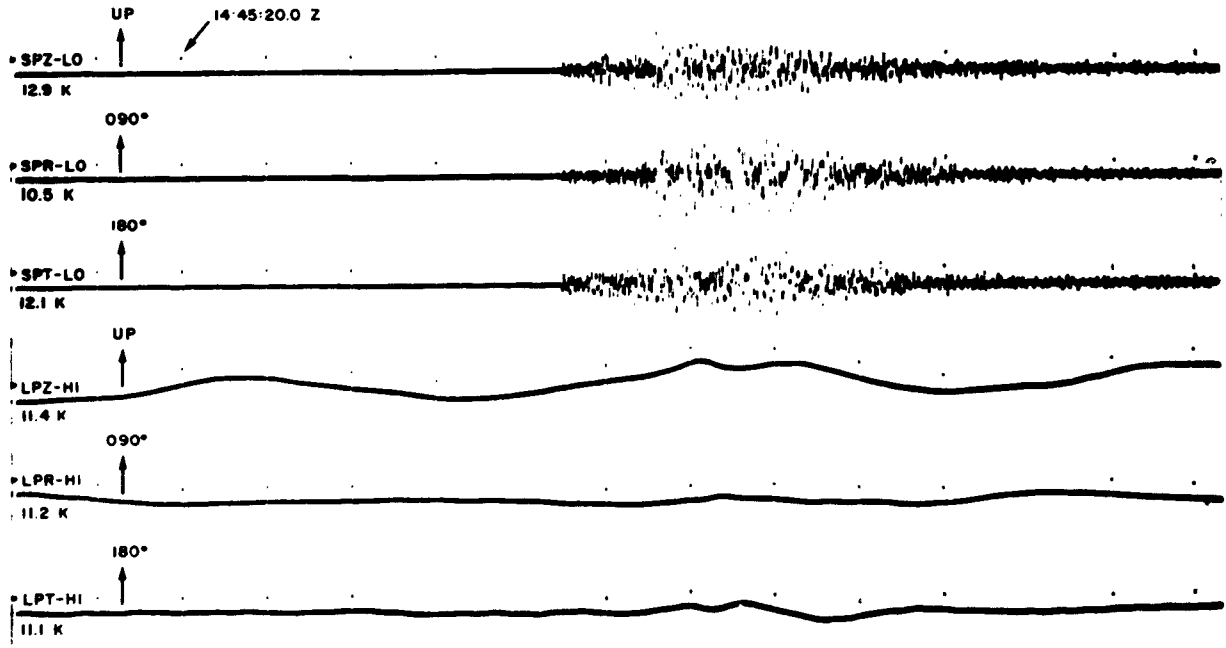
COLONA EARTHQUAKE

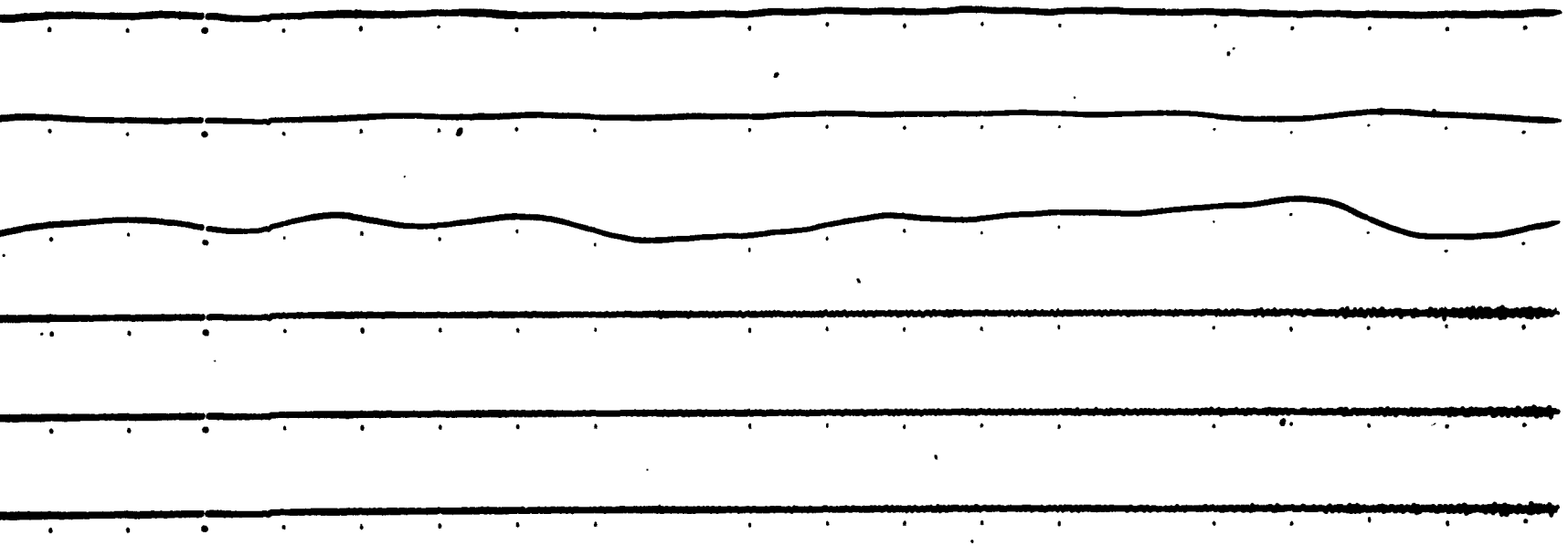
DR CO

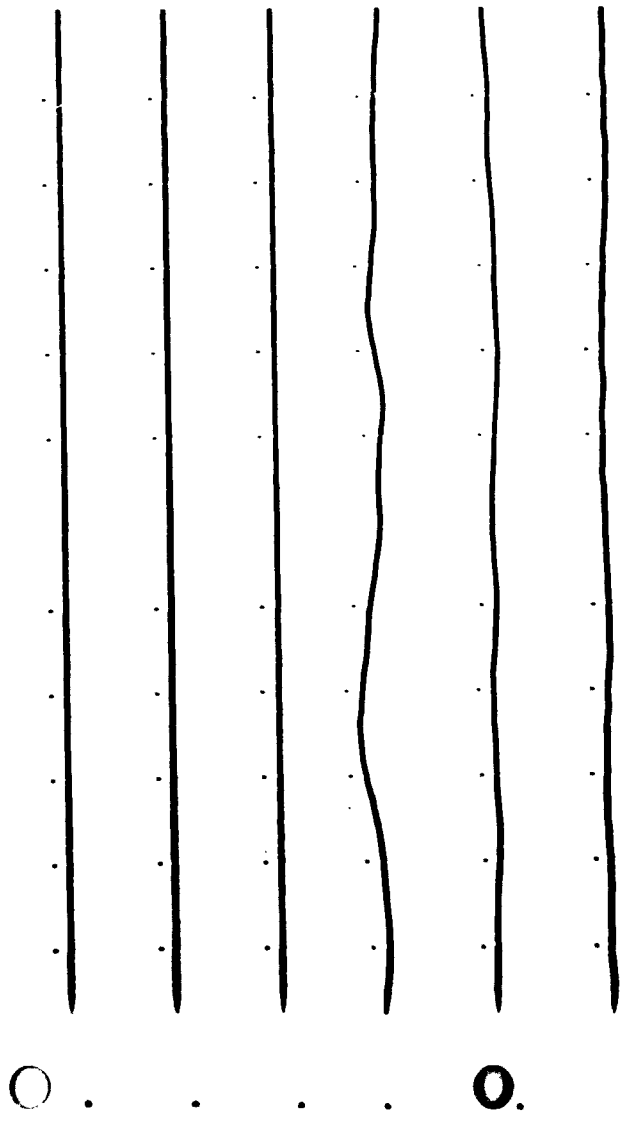
Durango, Colorado

5 February 1962

Δ = 83 km







Reoriented Horizontal Components

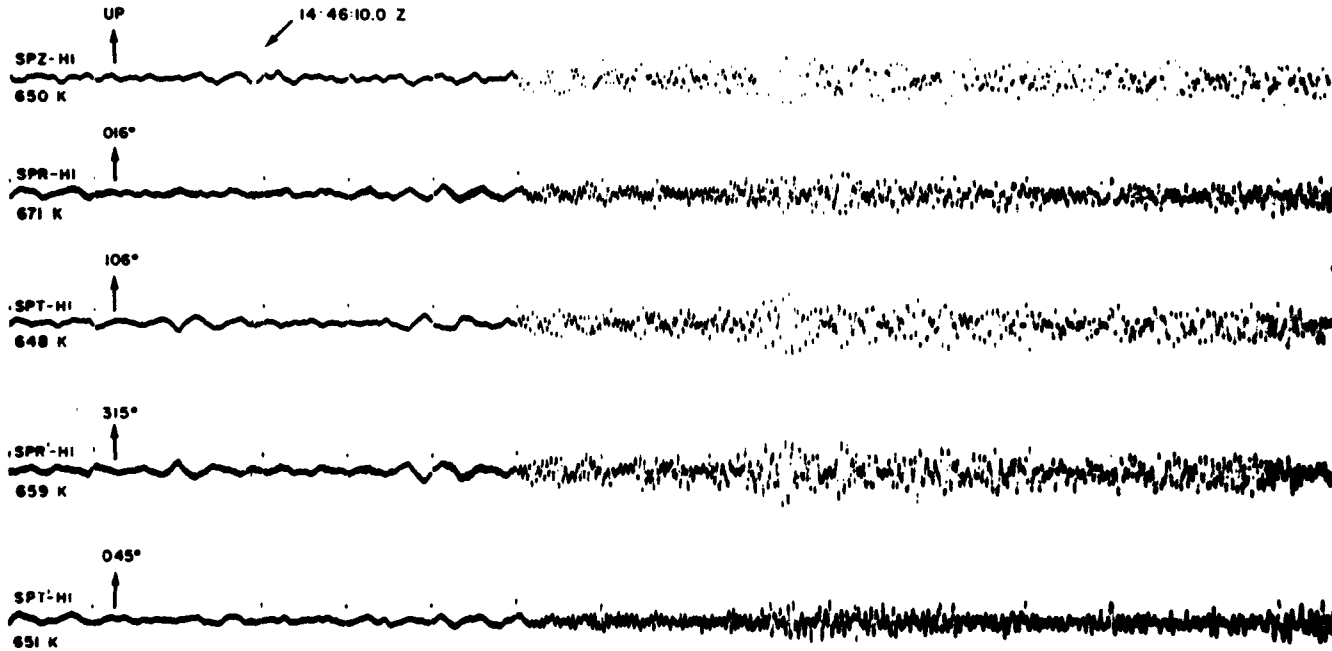
COLONA EARTHQUAKE

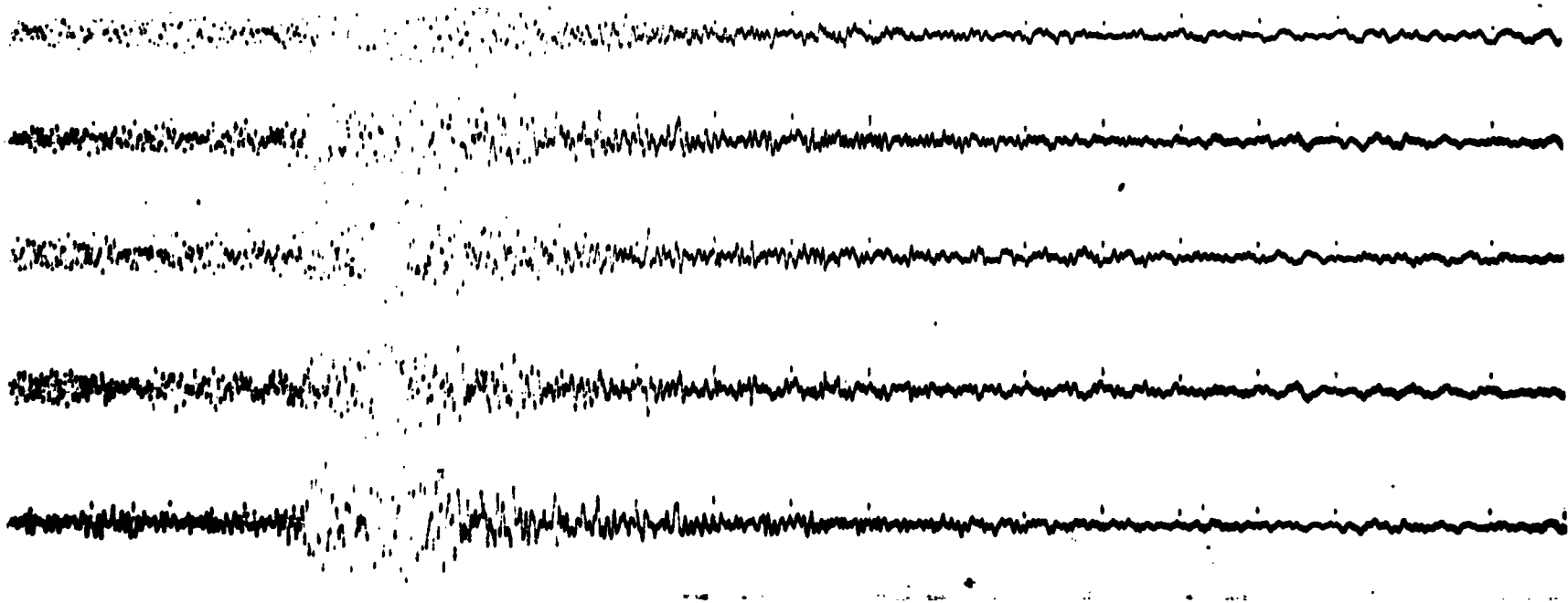
HL ID

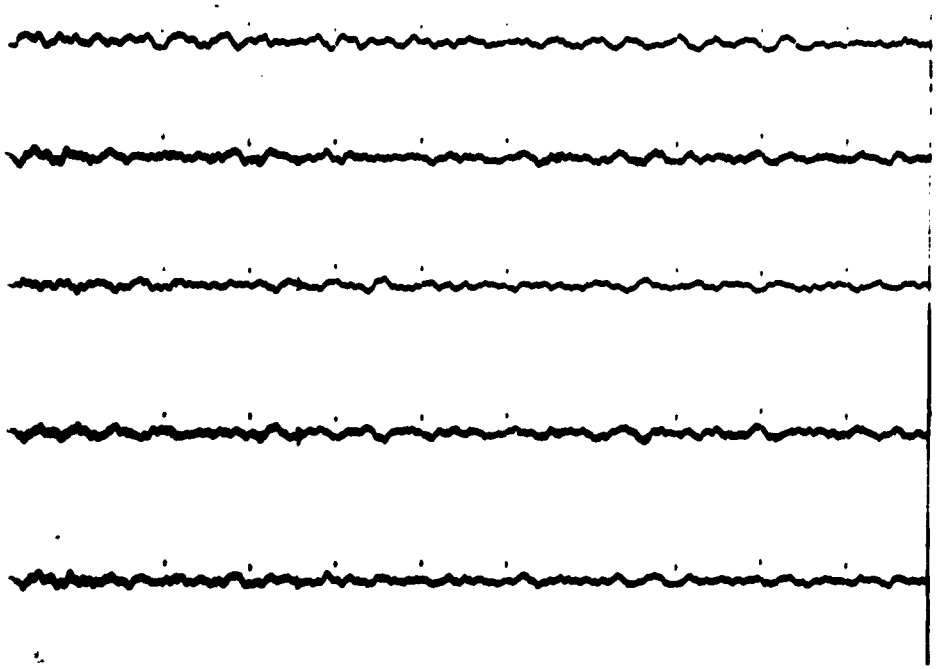
Hailey, Idaho

5 February 1962

Δ = 825 km







Reoriented Horizontal Components

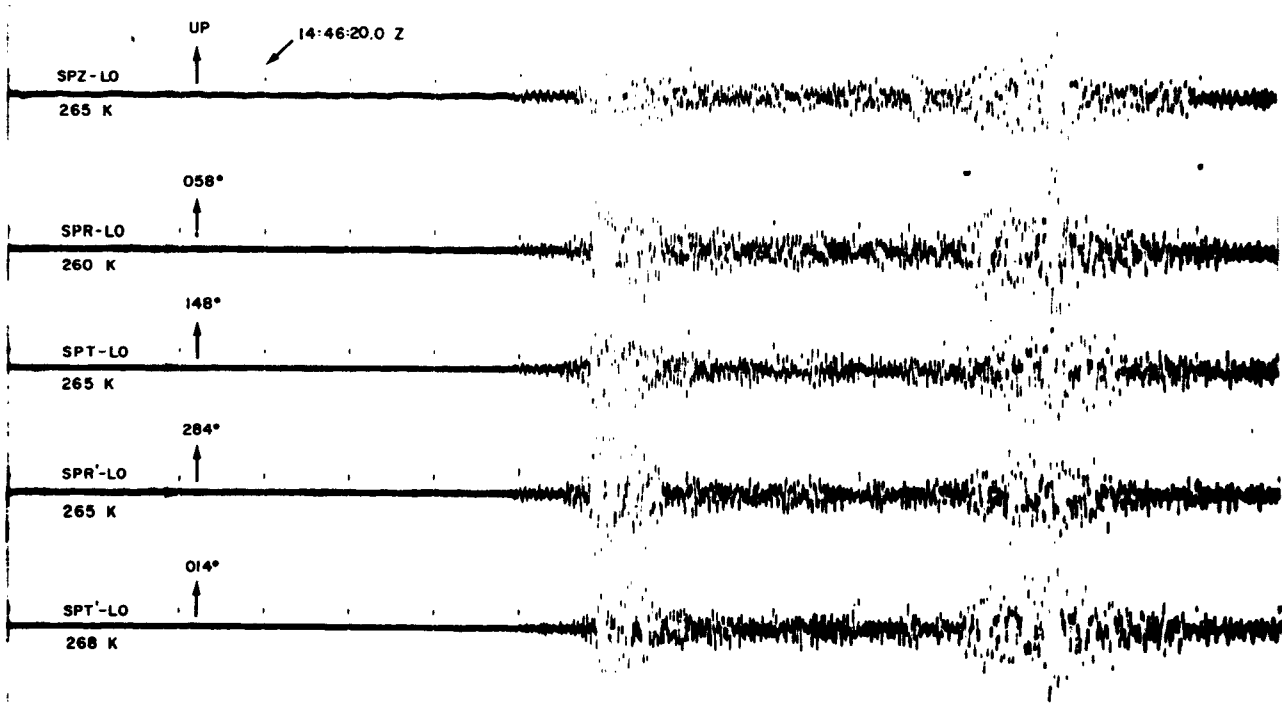
COLONA EARTHQUAKE

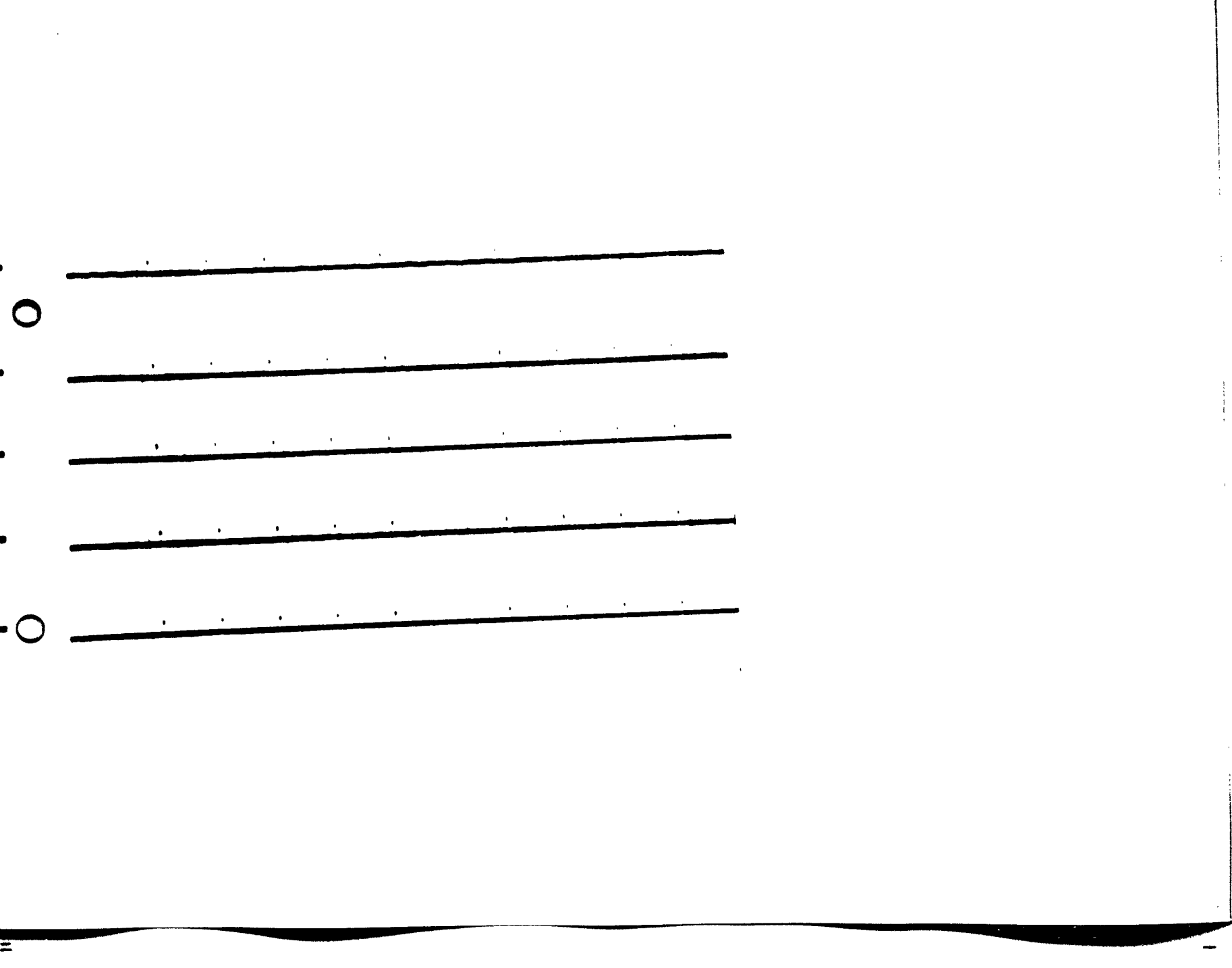
FM UT

Fillmore, Utah

5 February 1962

Δ = 416 km





Reoriented Horizontal Components

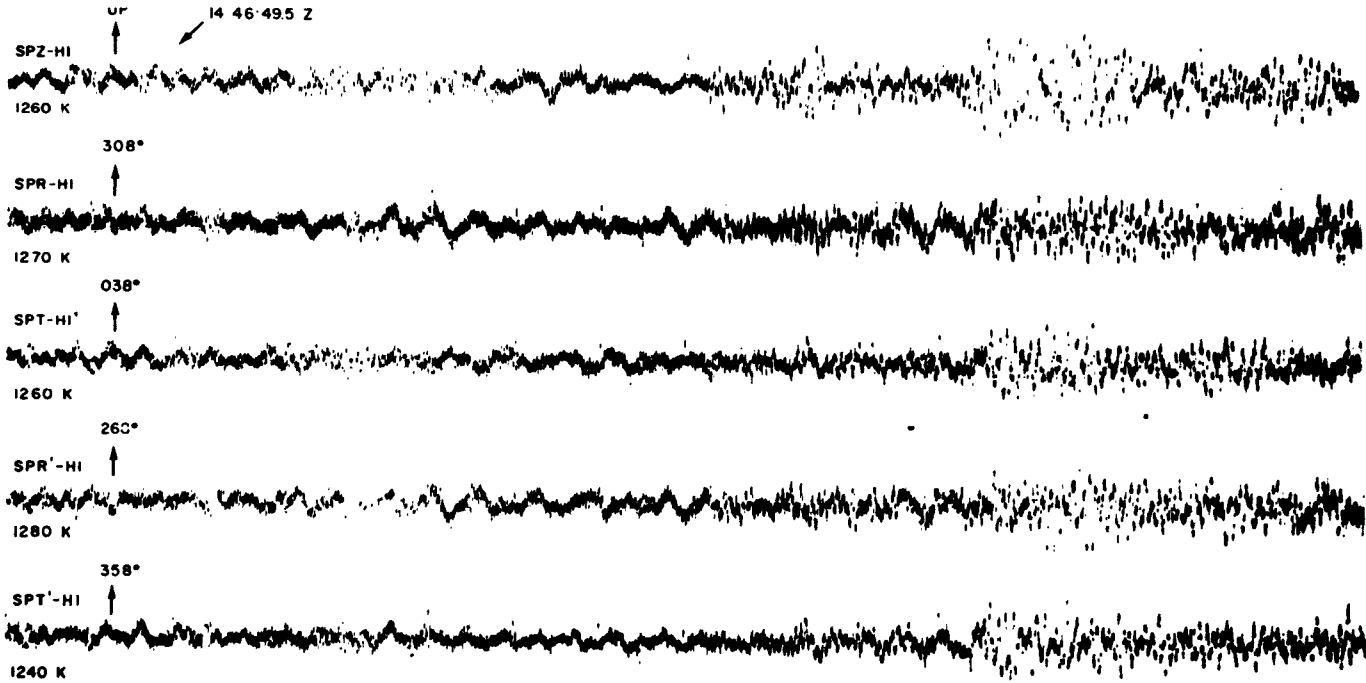
COLONA EARTHQUAKE

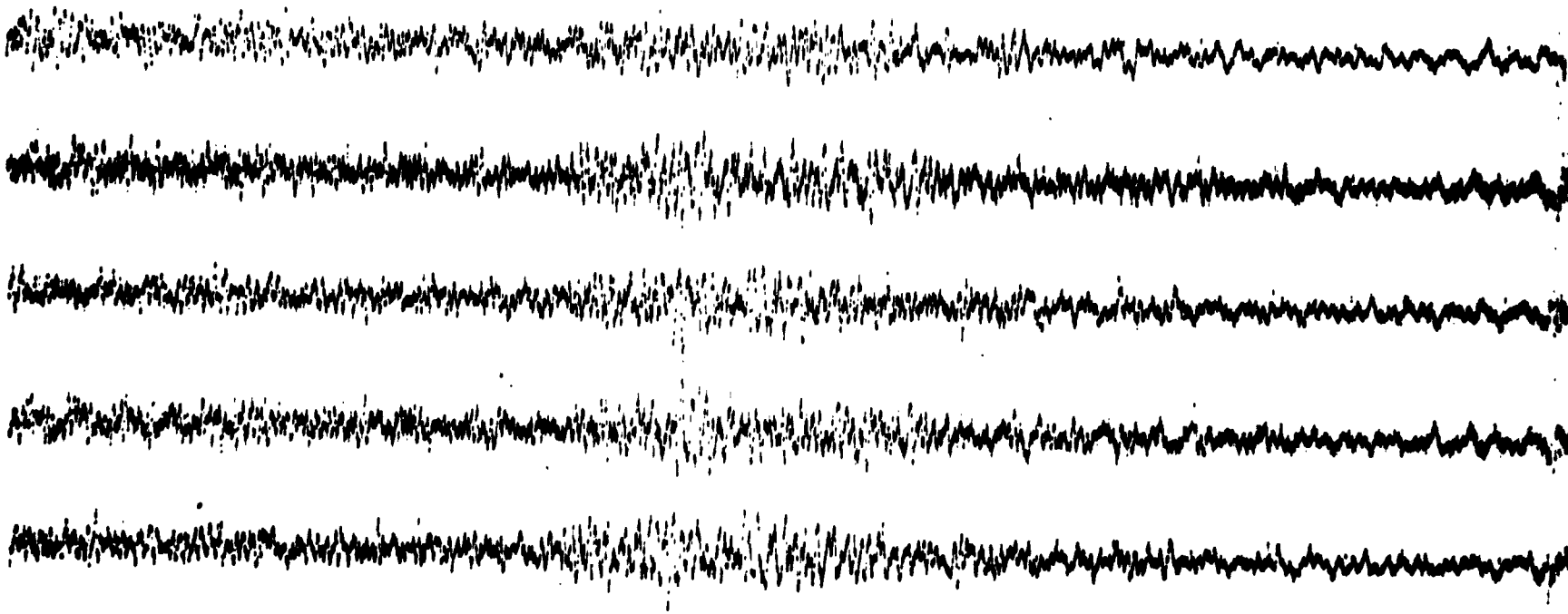
MN NV

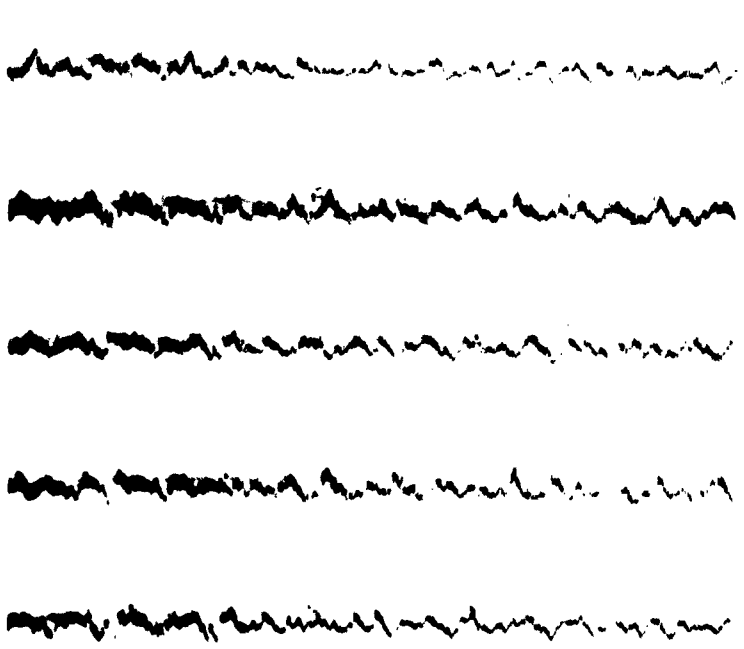
Mina, Nevada

5 February, 1962

Δ=923 km







Reoriented Horizontal Components

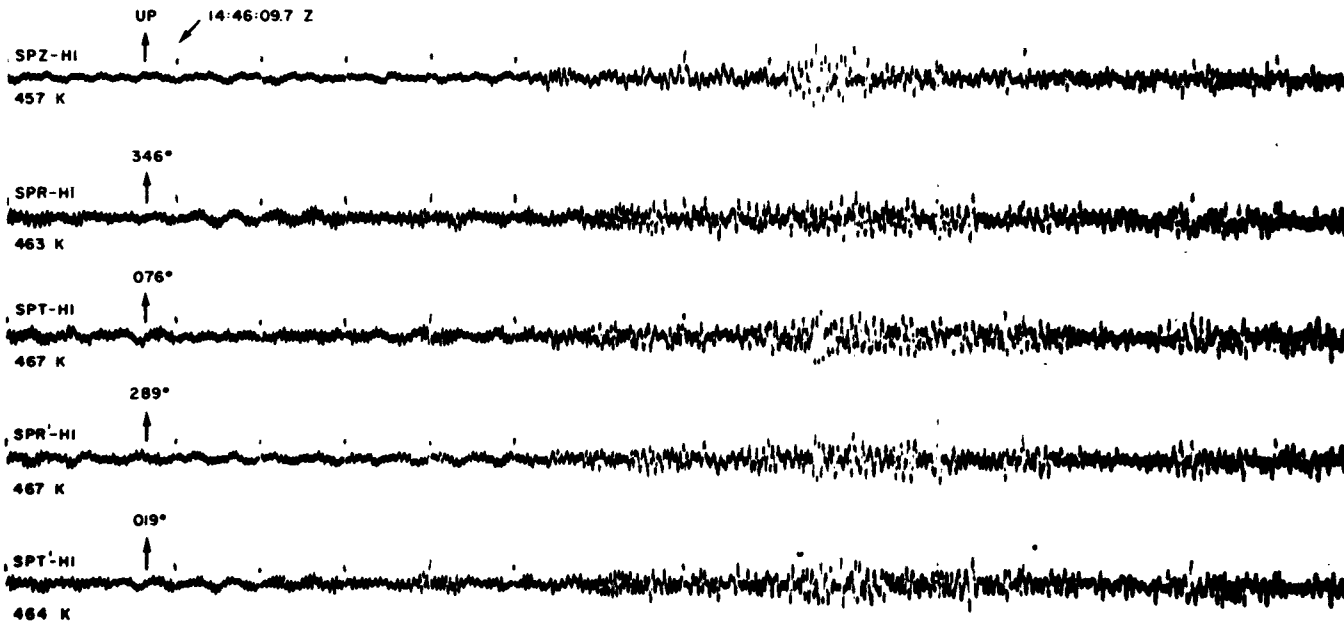
COLONA EARTHQUAKE

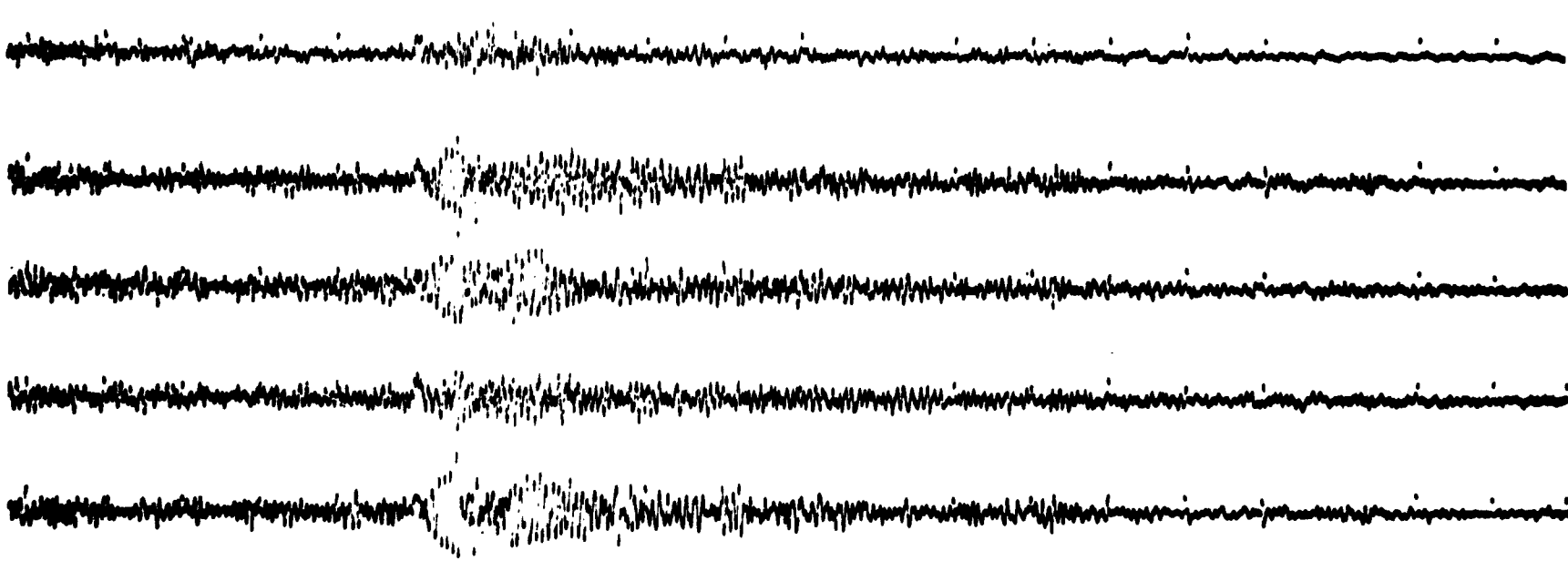
WI NV

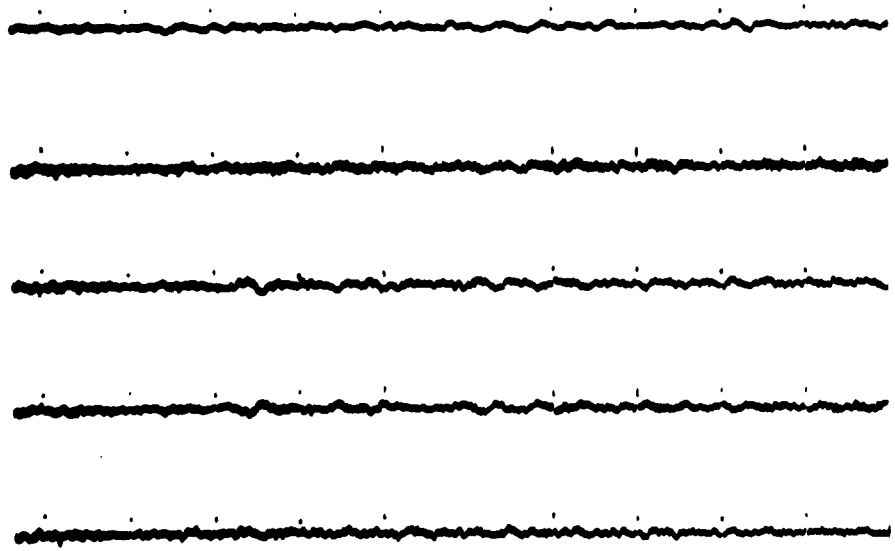
Winnemucca, Nevada

5 February 1962

Δ = 914 km







Rerecorded Horizontal Components

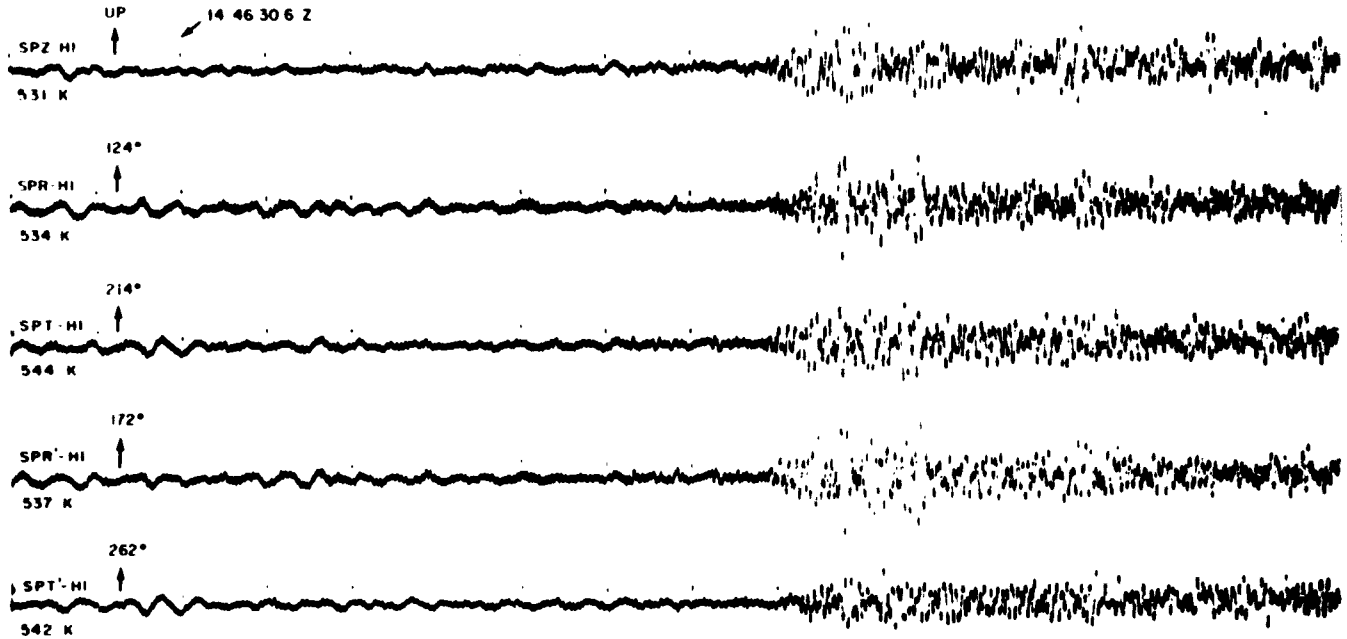
COLONA EARTHQUAKE

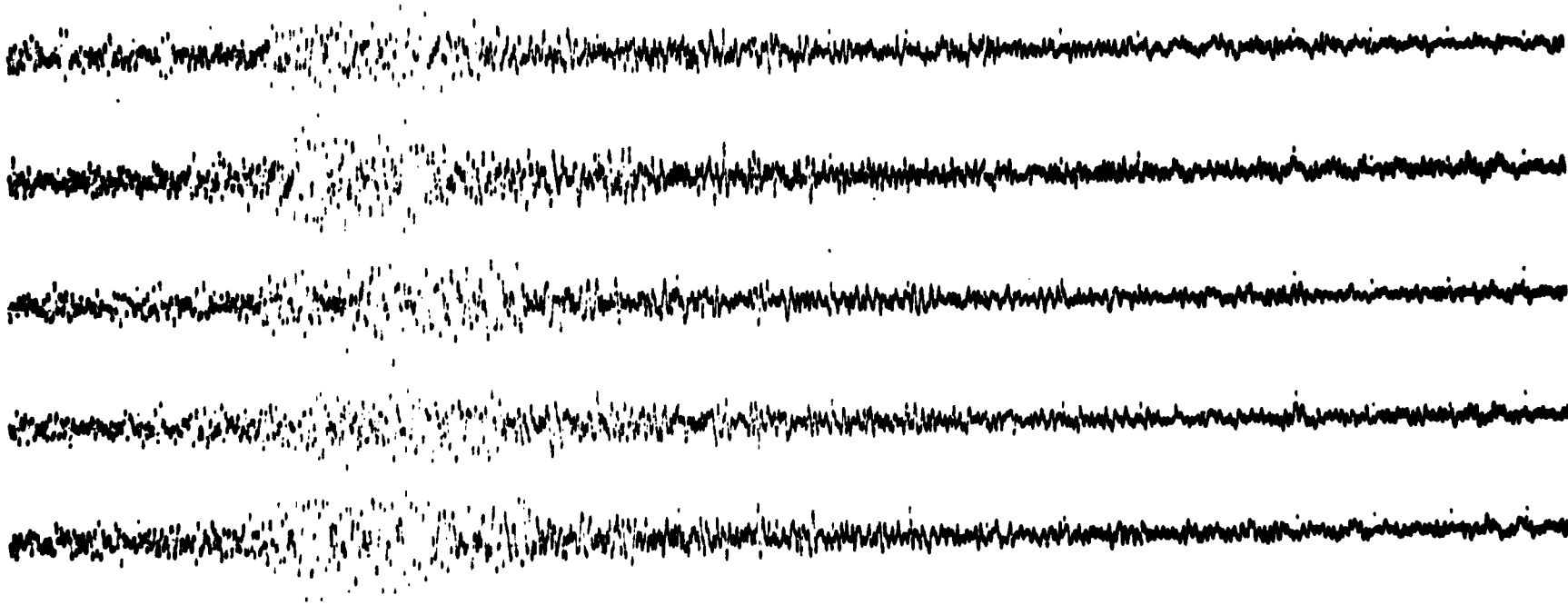
LC NM

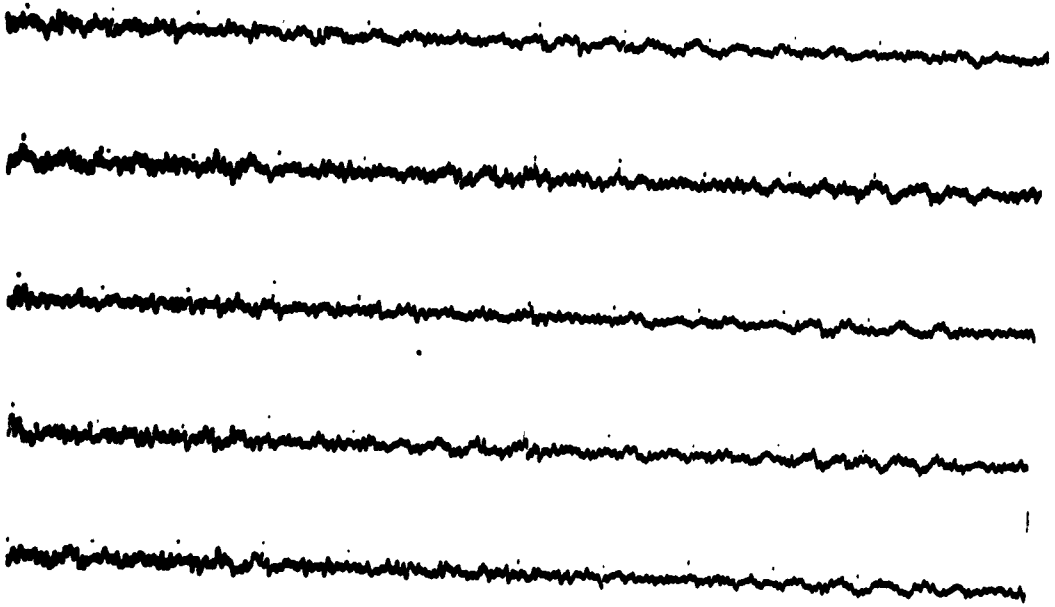
Las Cruces, New Mexico

5 February 1962

Δ = 650 km







Reoriented Horizontal Components

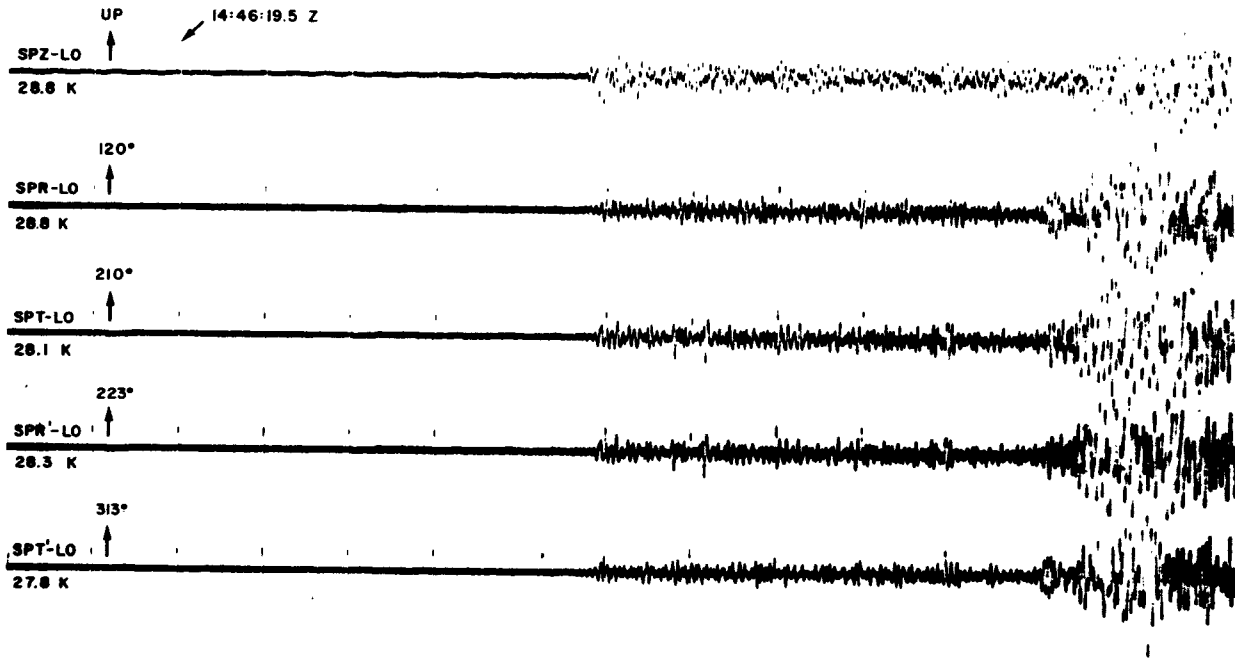
COLONA EARTHQUAKE

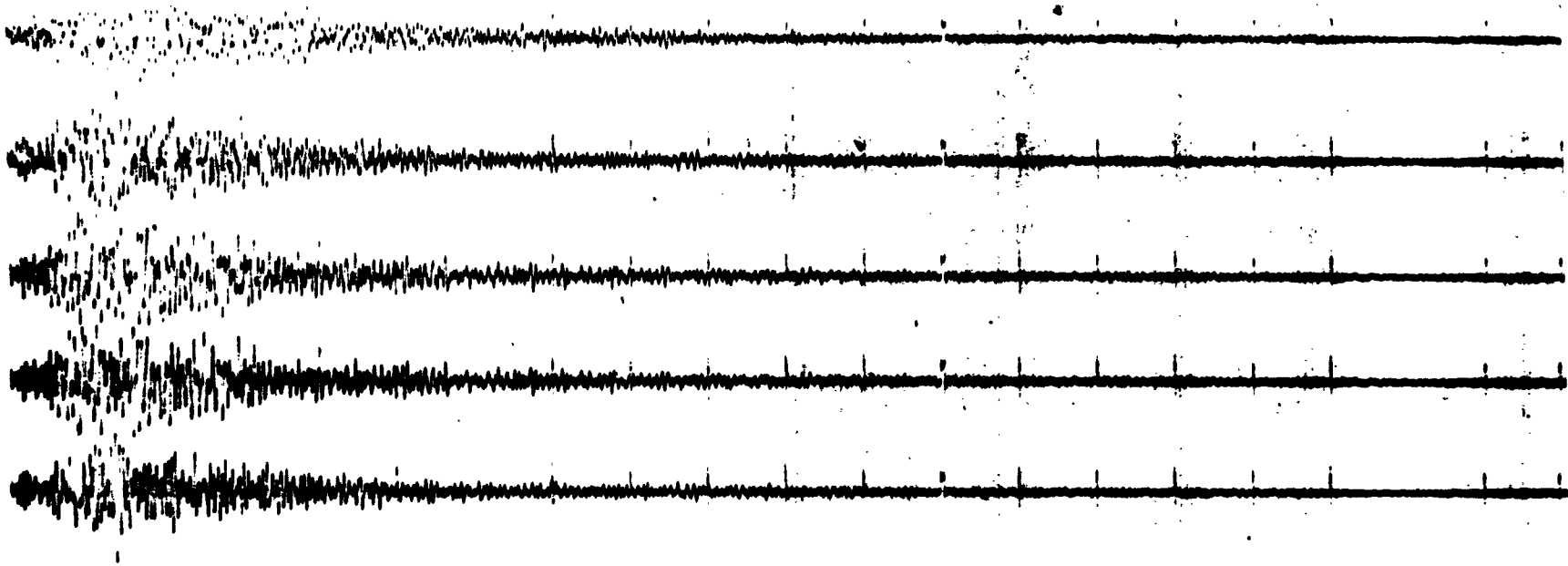
FS AZ

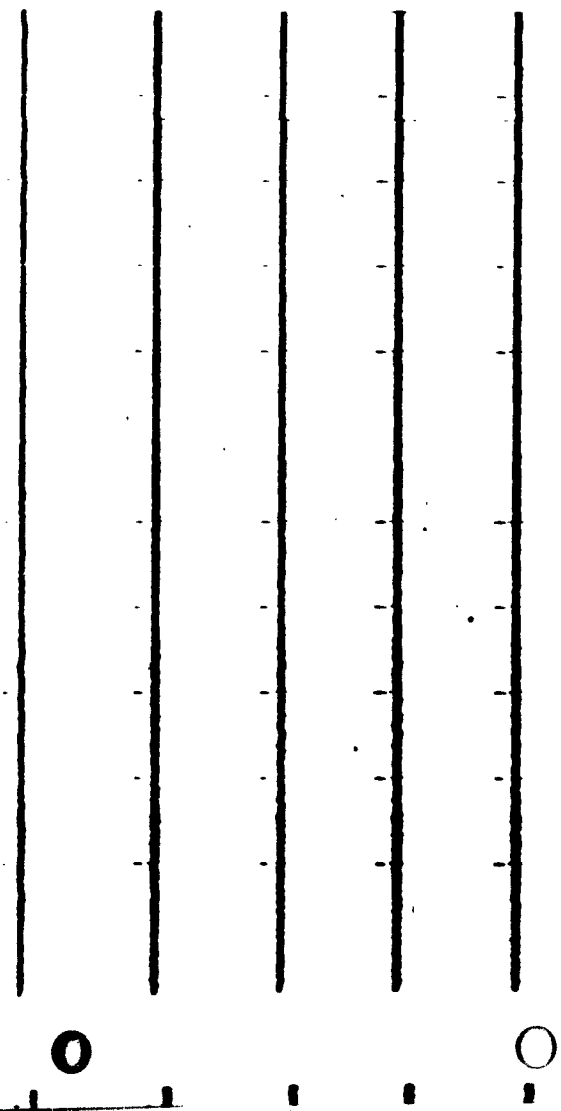
Flagstaff, Arizona

5 February 1962

Δ = 480 km







Reoriented Horizontal Components

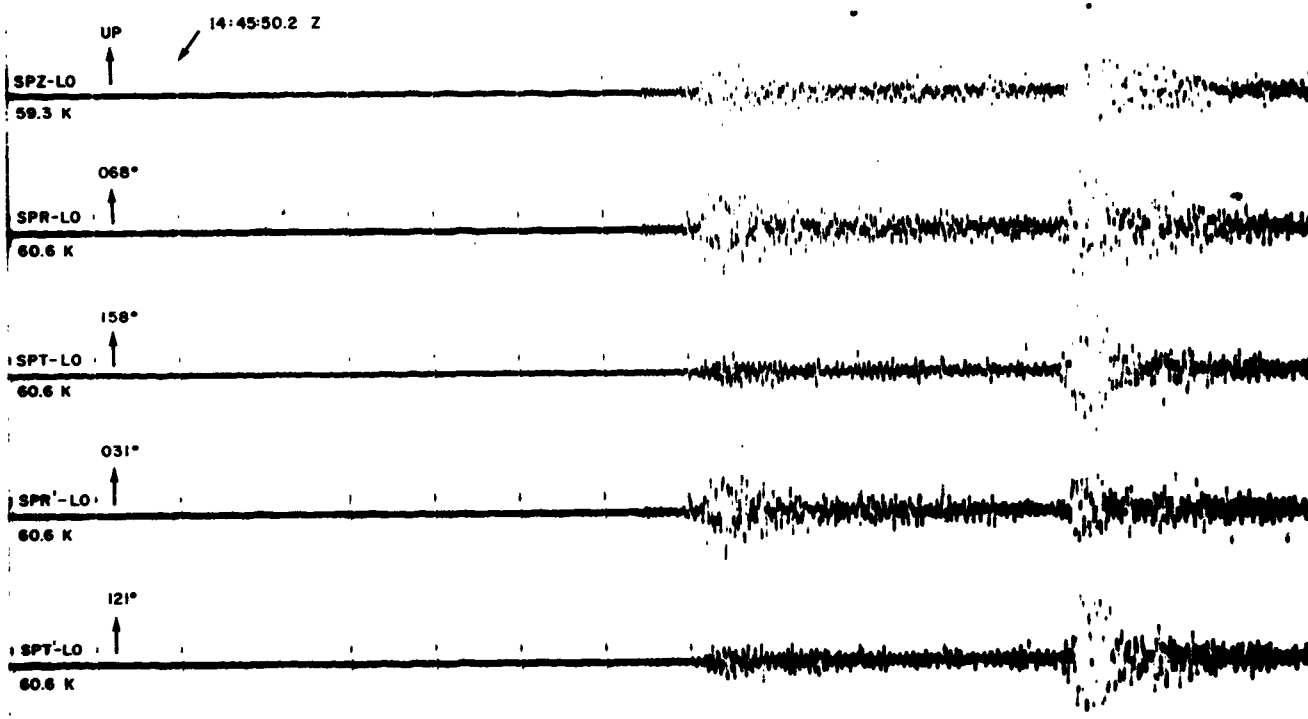
COLONA EARTHQUAKE

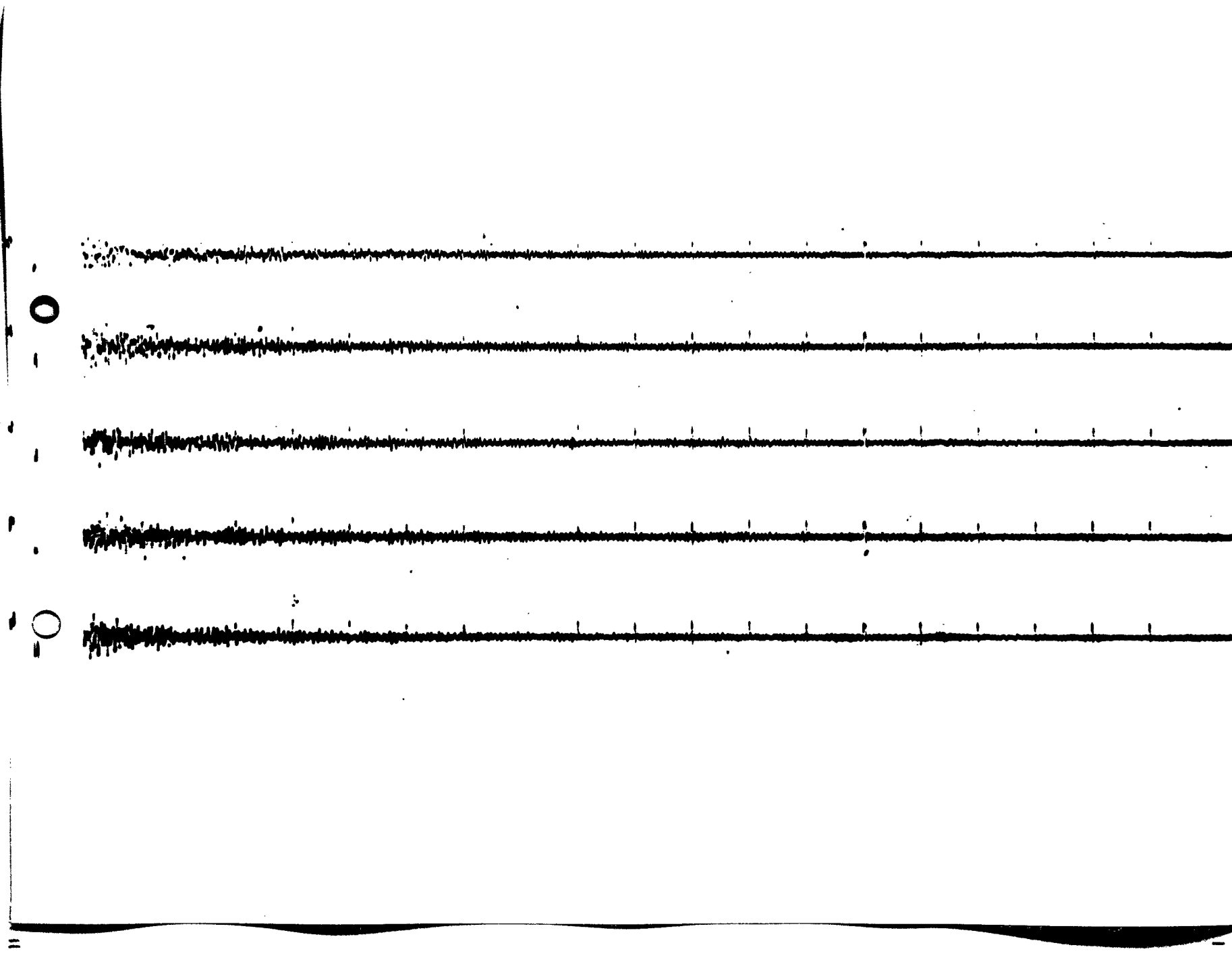
PM WY

Pole Mountain, Wyoming

5 February 1962

Δ = 385 km





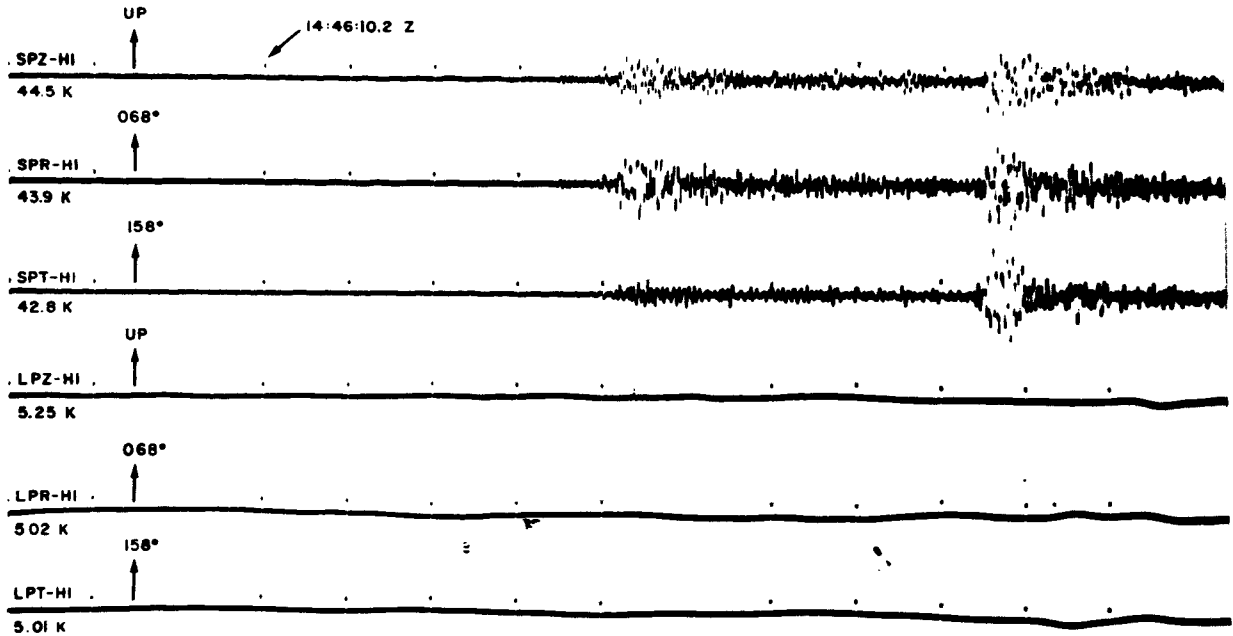
COLONA EARTHQUAKE

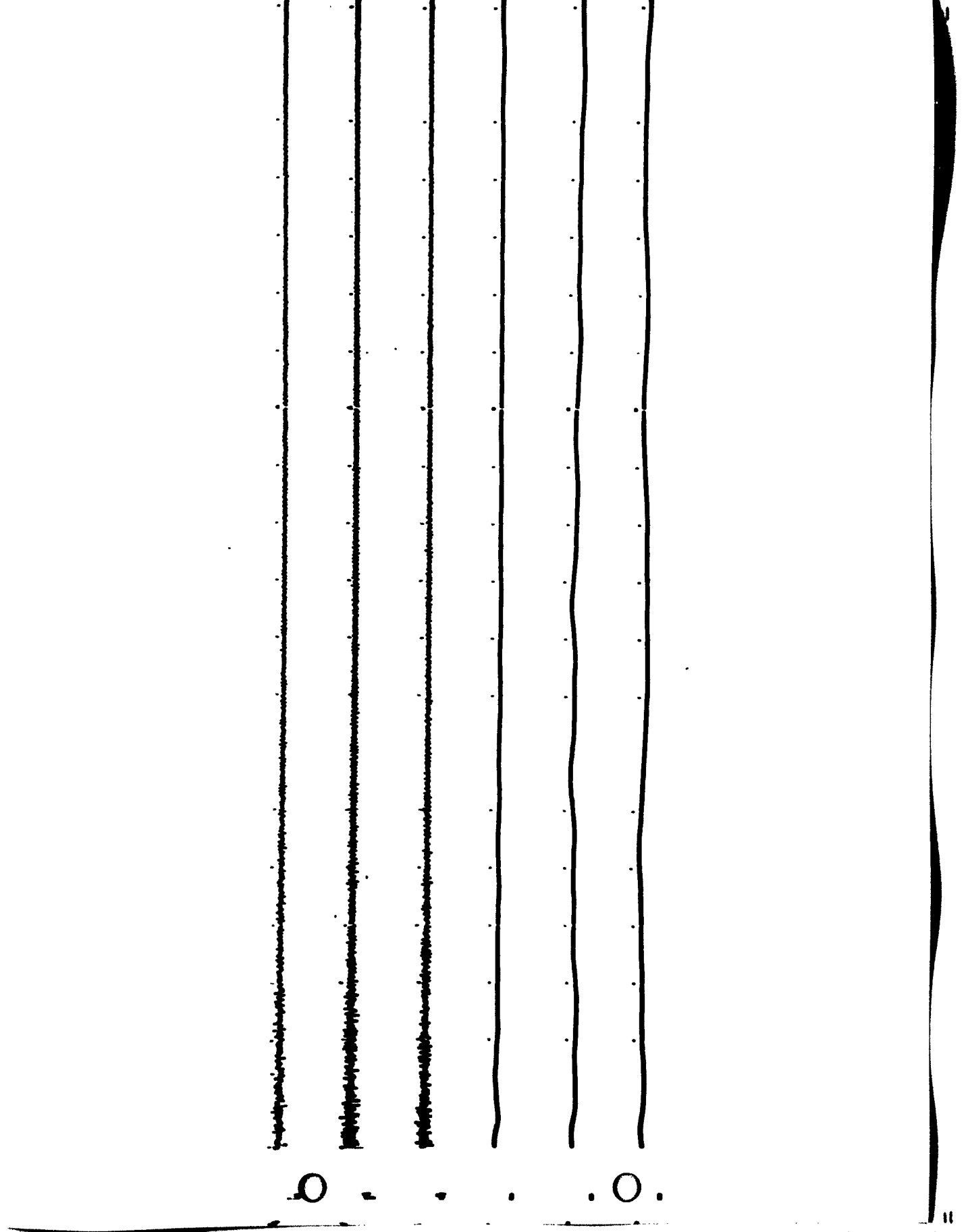
PM WY

Pole Mountain, Wyoming

5 February 1962

Δ=385 km





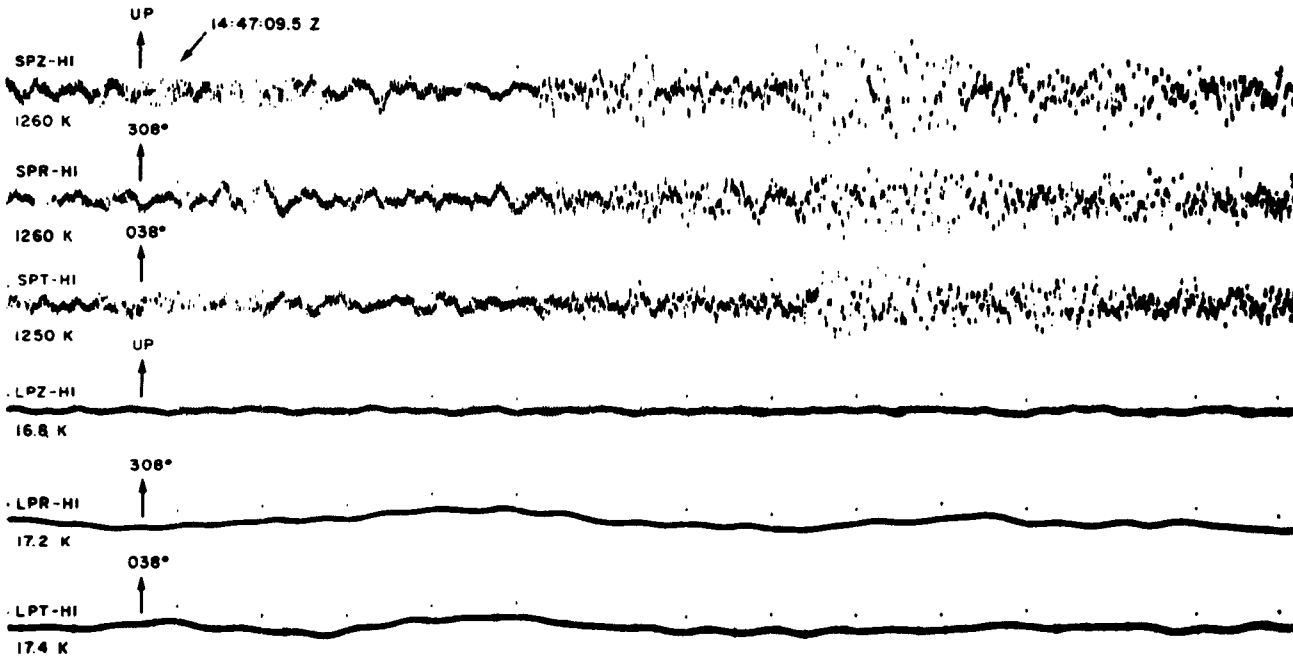
COLONA EARTHQUAKE

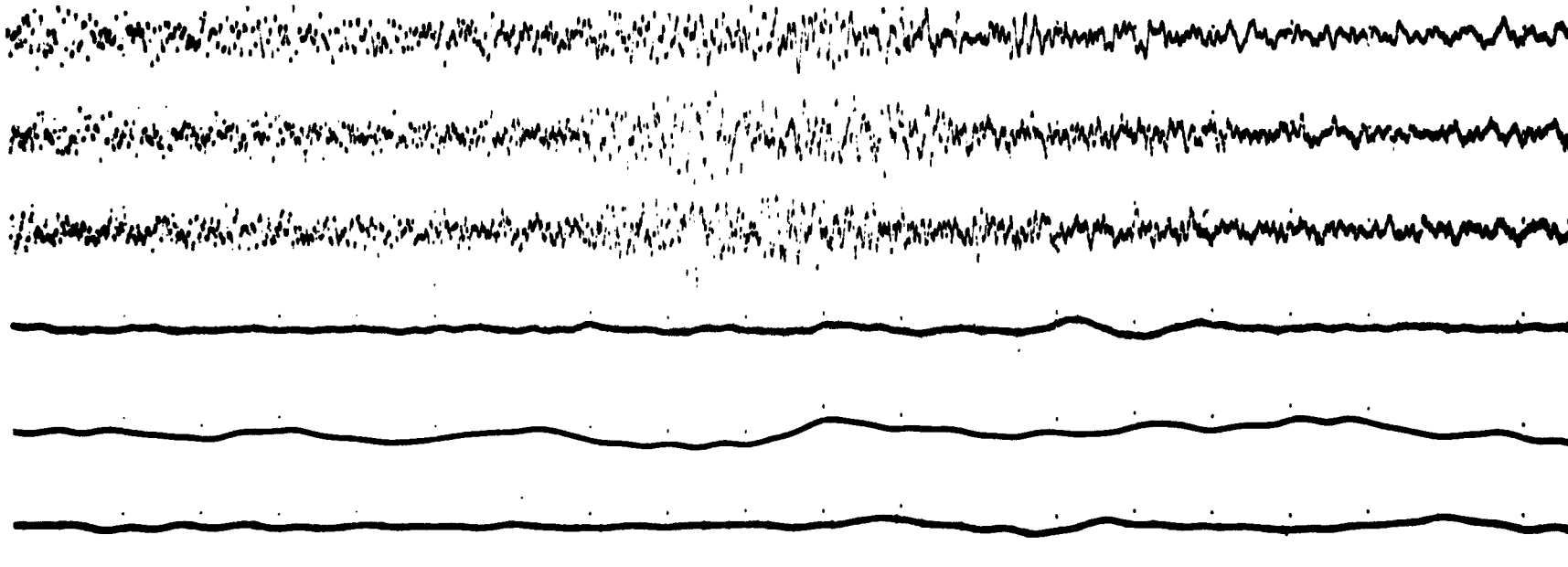
MN XV

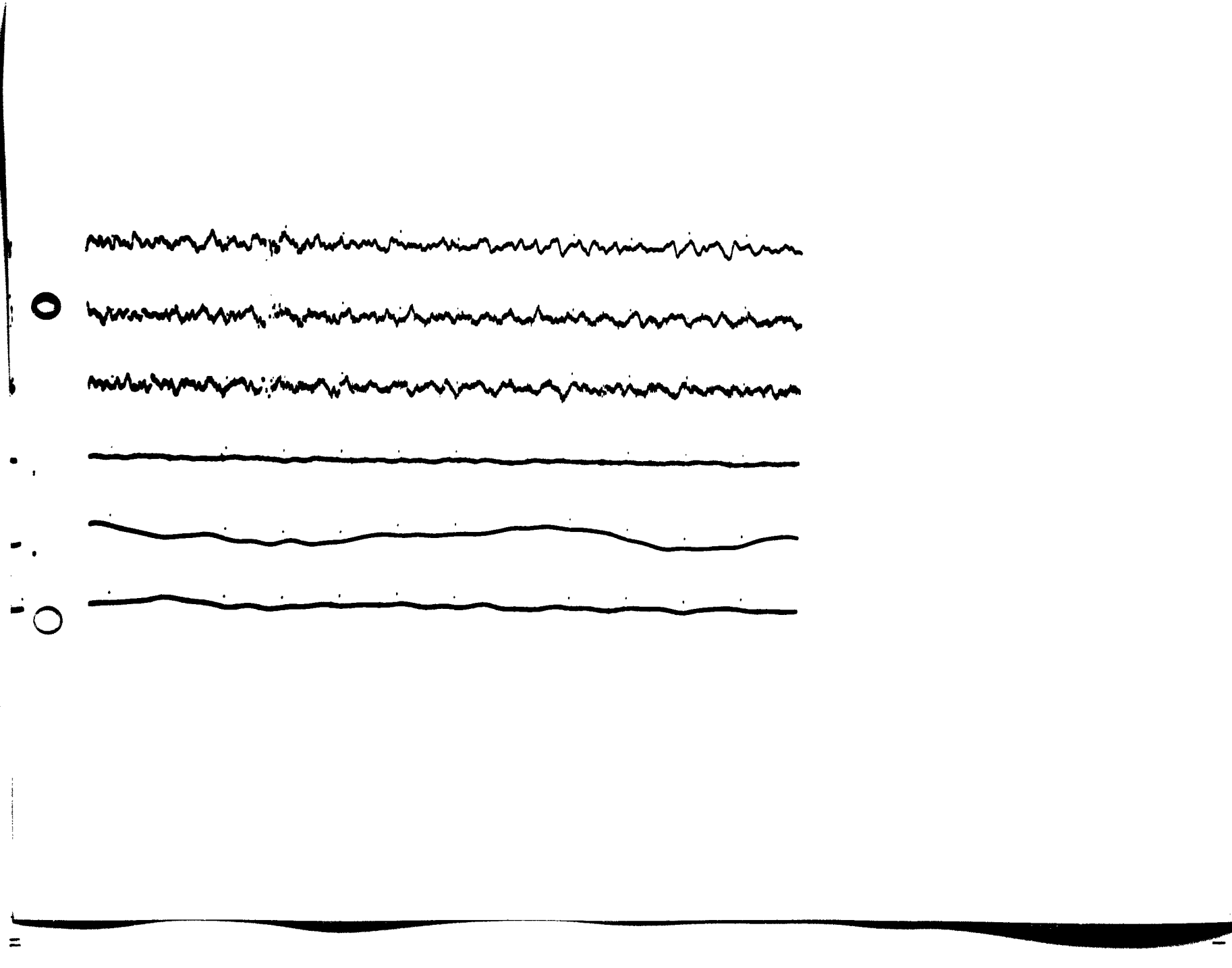
Mina, Nevada

5 February 1962

Δ=923 km







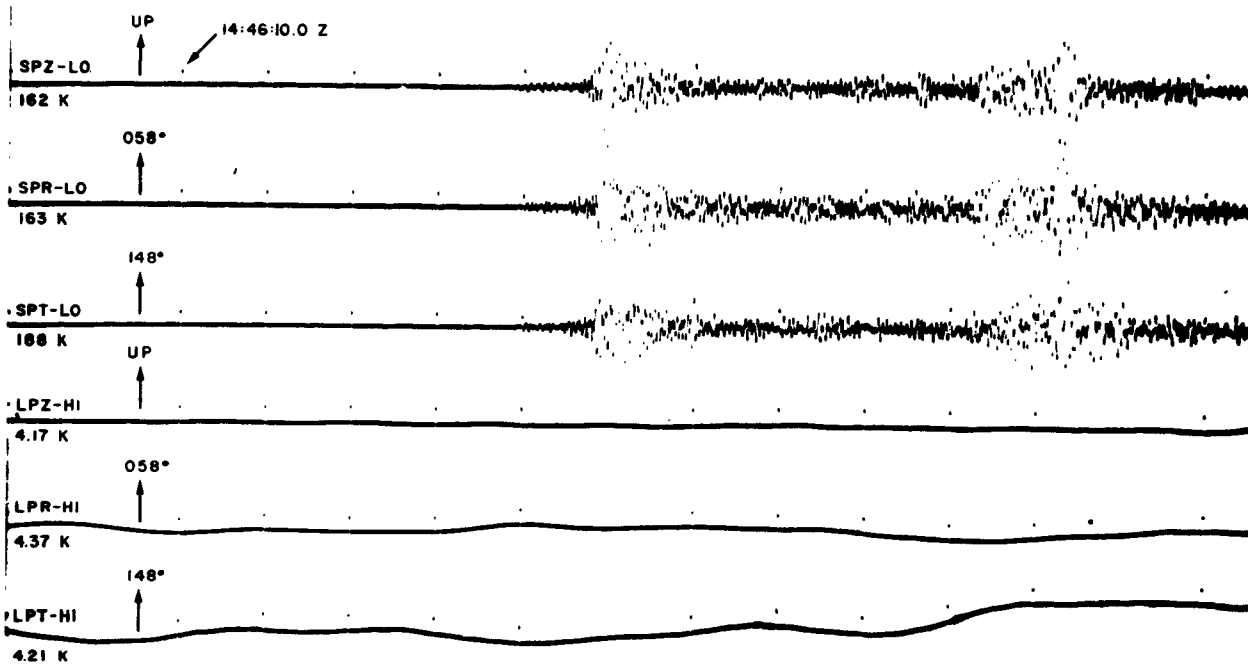
COLONA EARTHQUAKE

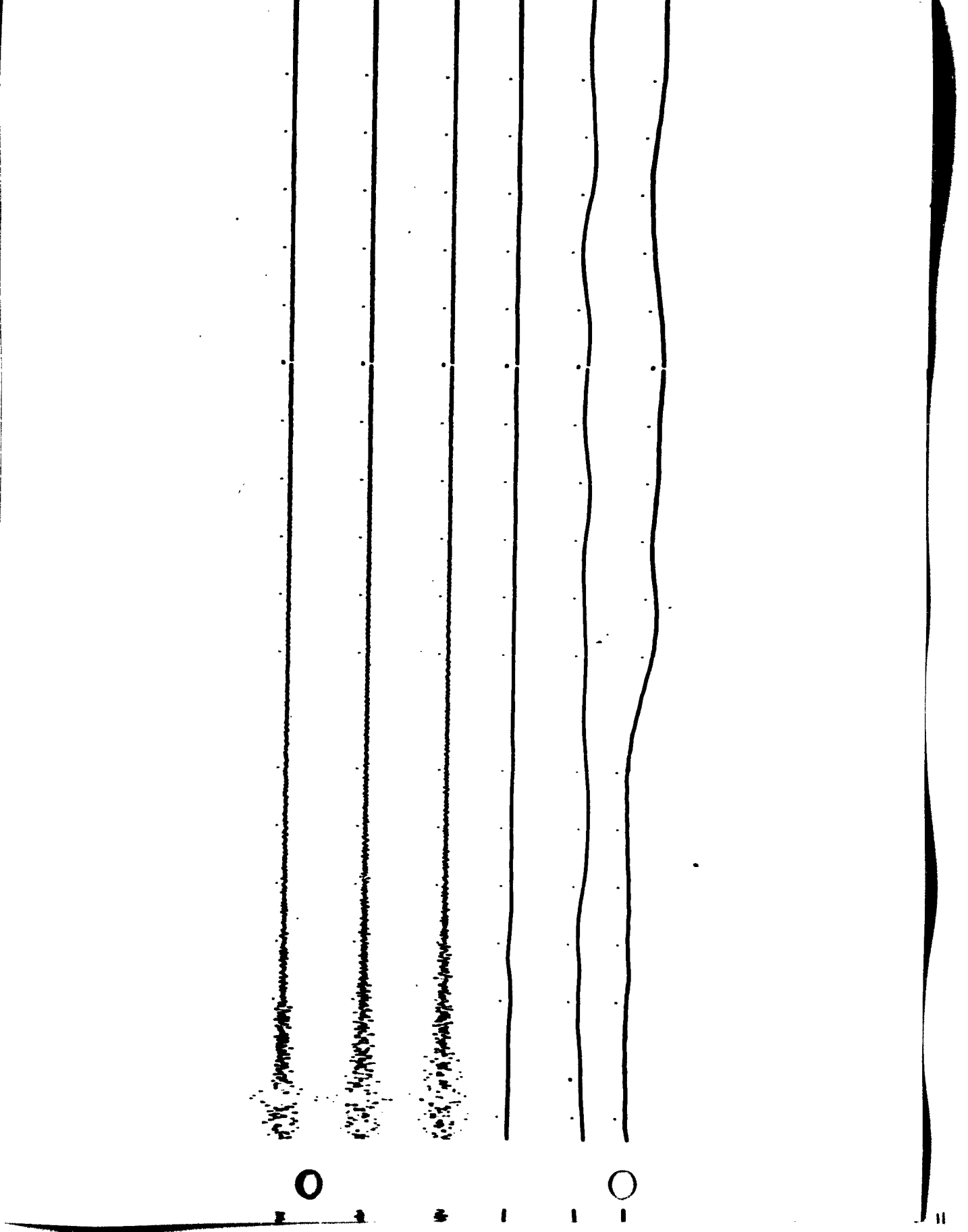
FM UT

Fillmore, Utah

5 February 1962

Δ = 416 km





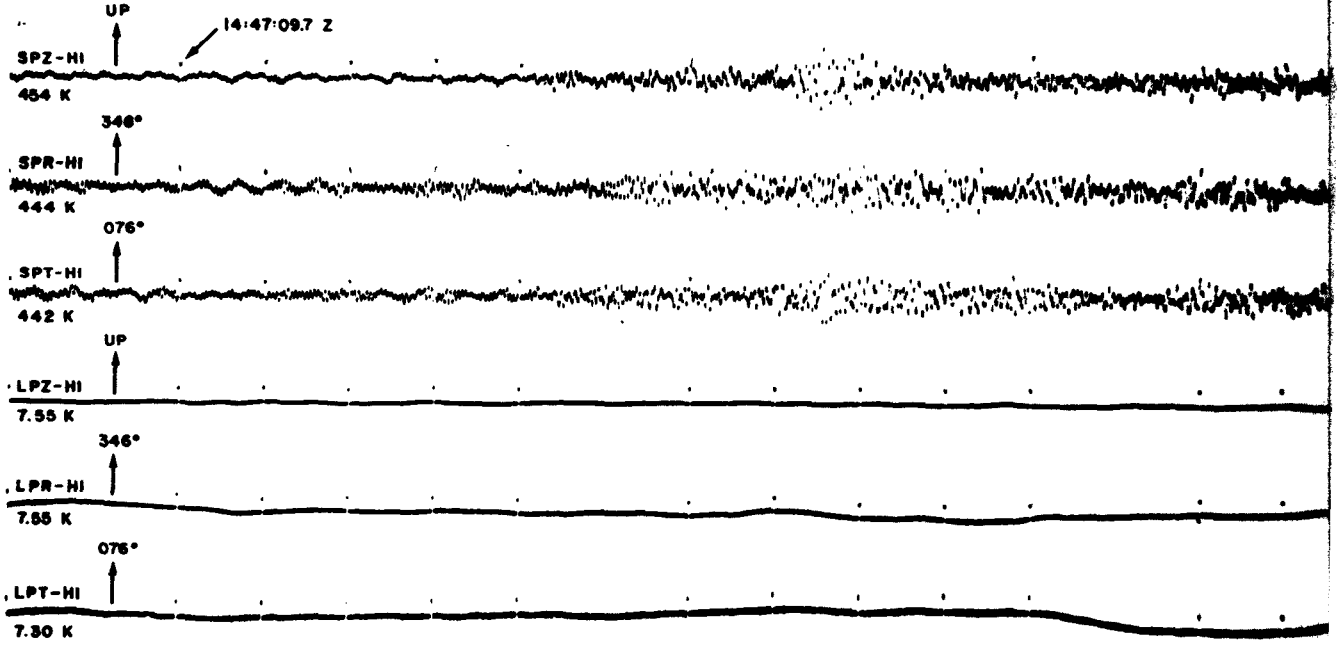
COLONA EARTHQUAKE

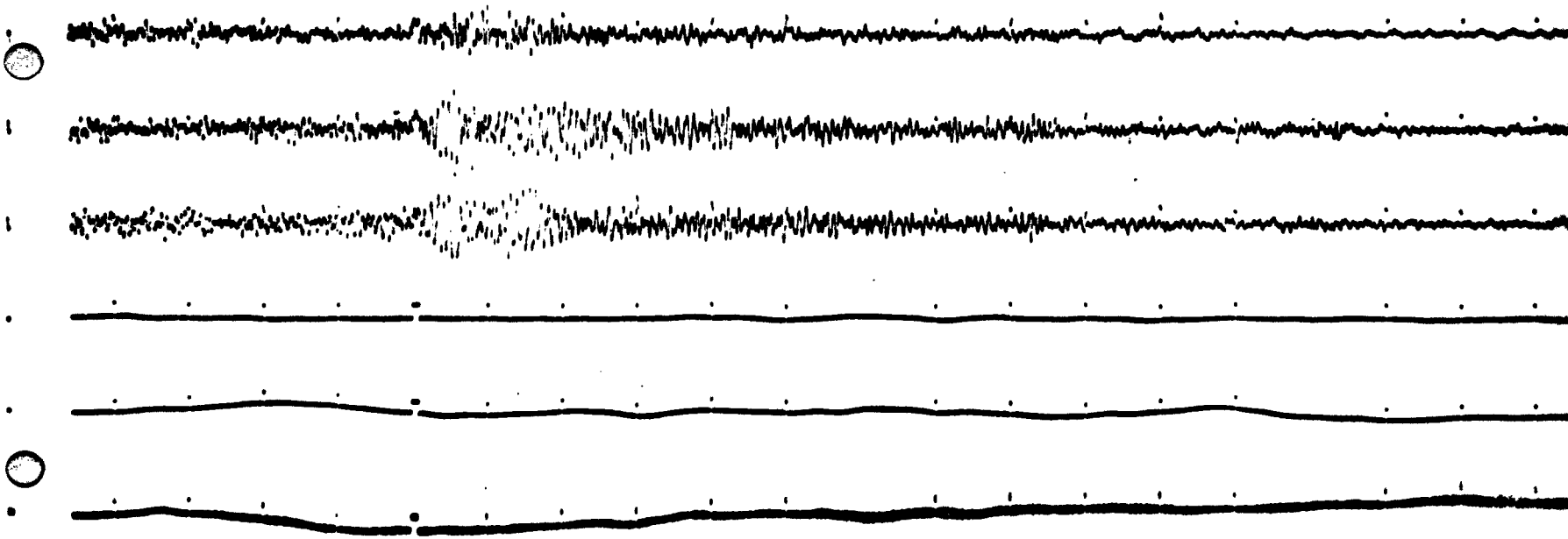
WI NV

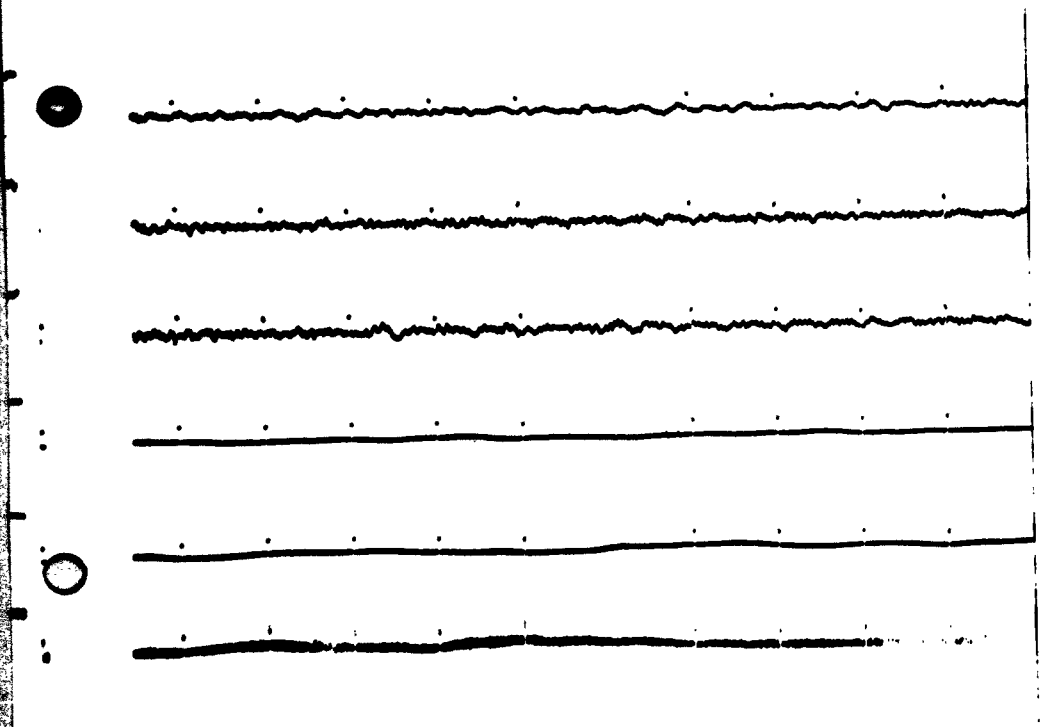
Winnemucca, Nevada

5 February 1962

Δ=914 km







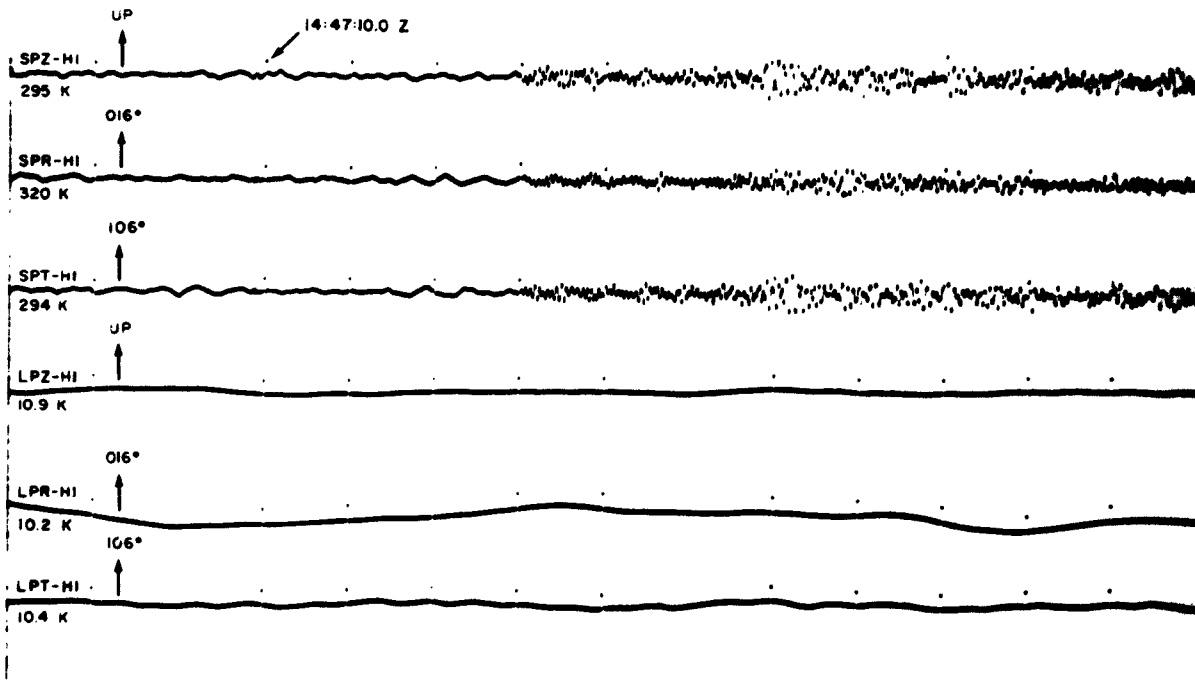
COLONA EARTHQUAKE

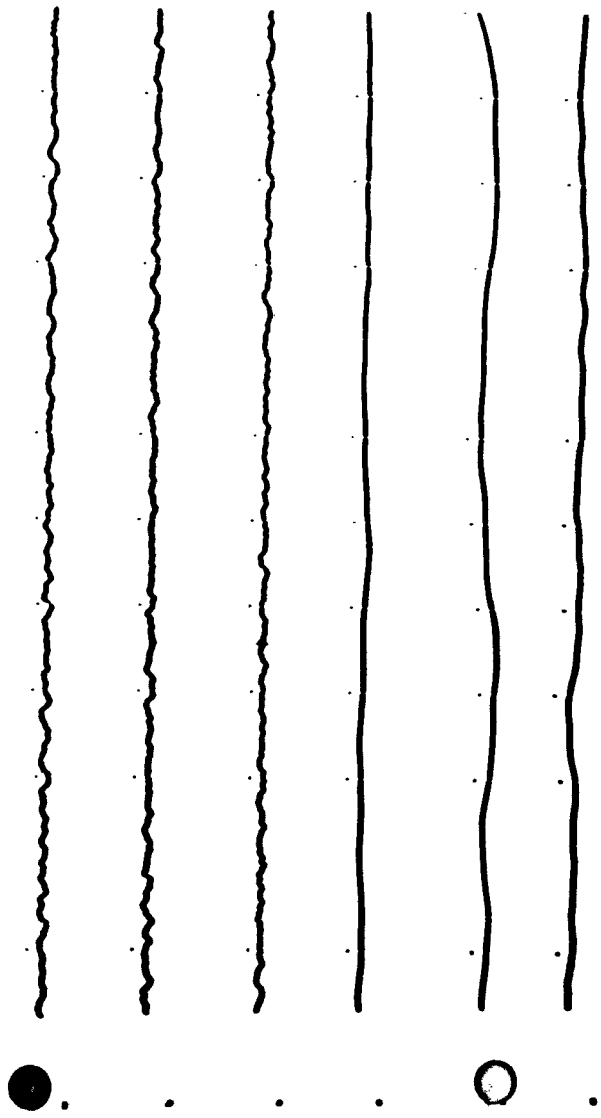
HL ID

Hailey, Idaho

5 February 1962

Δ = 825 km





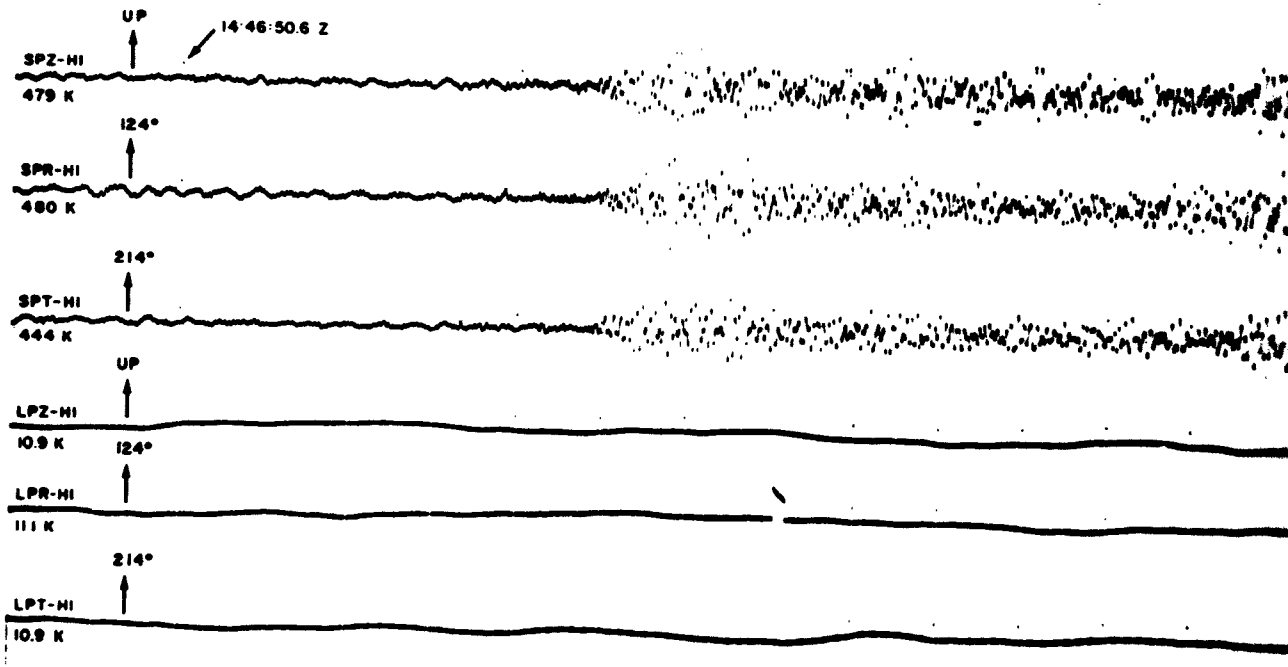
COLONA EARTHQUAKE

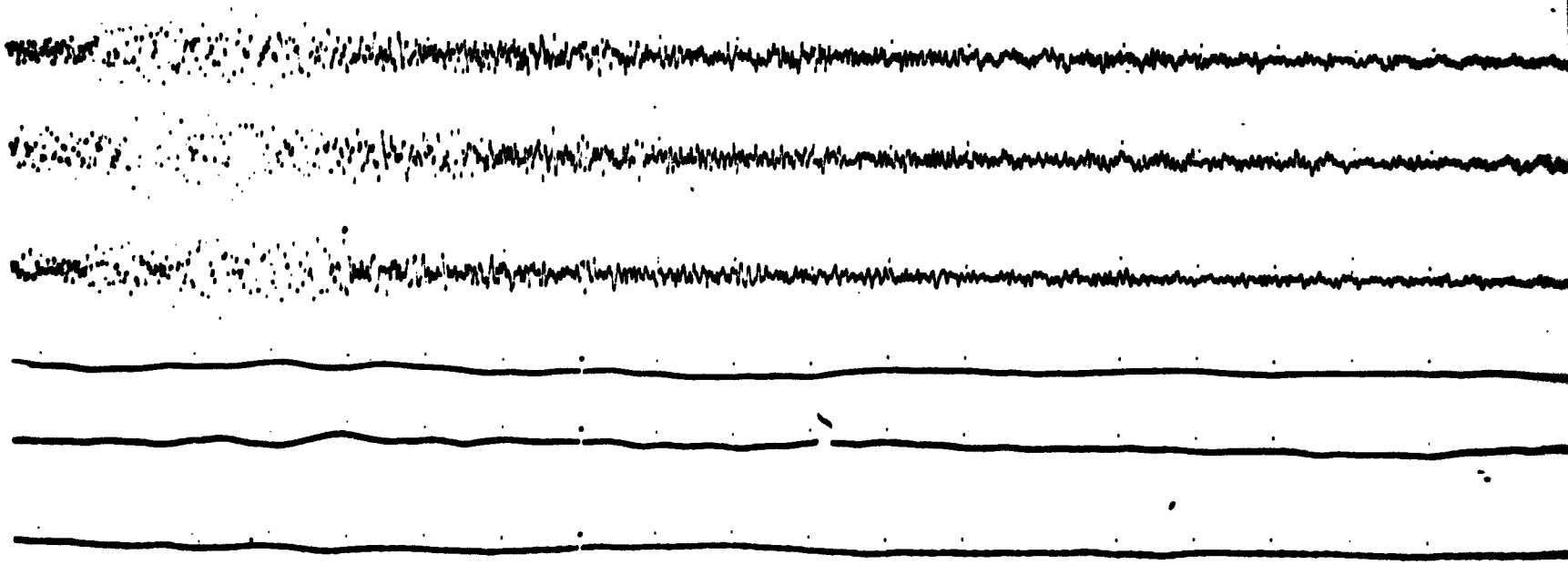
LC NM

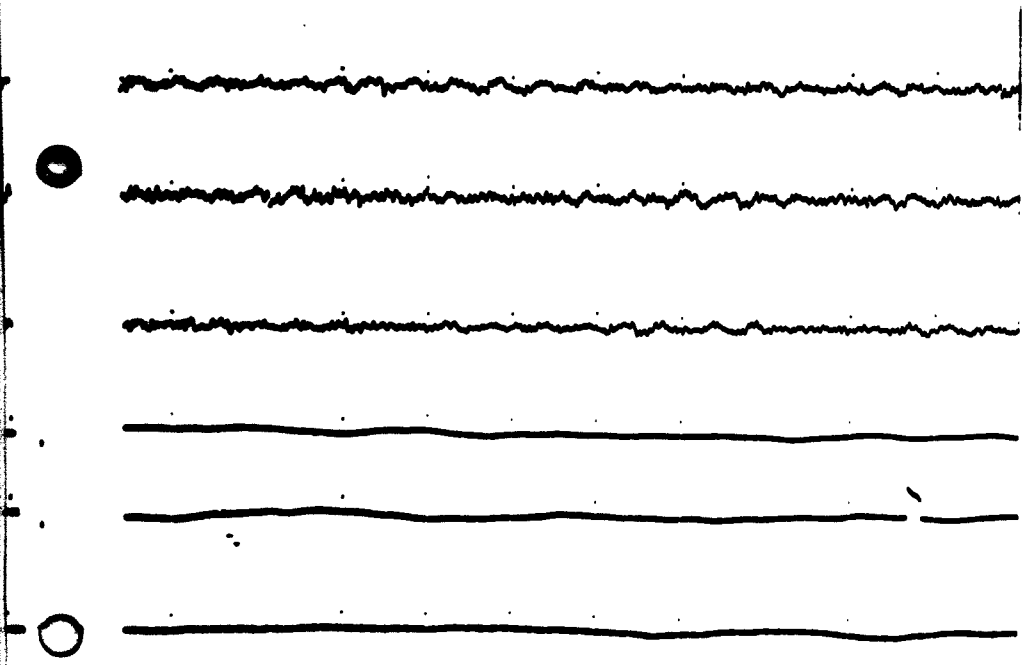
Las Cruces, New Mexico

5 February 1962

Δ=650 km







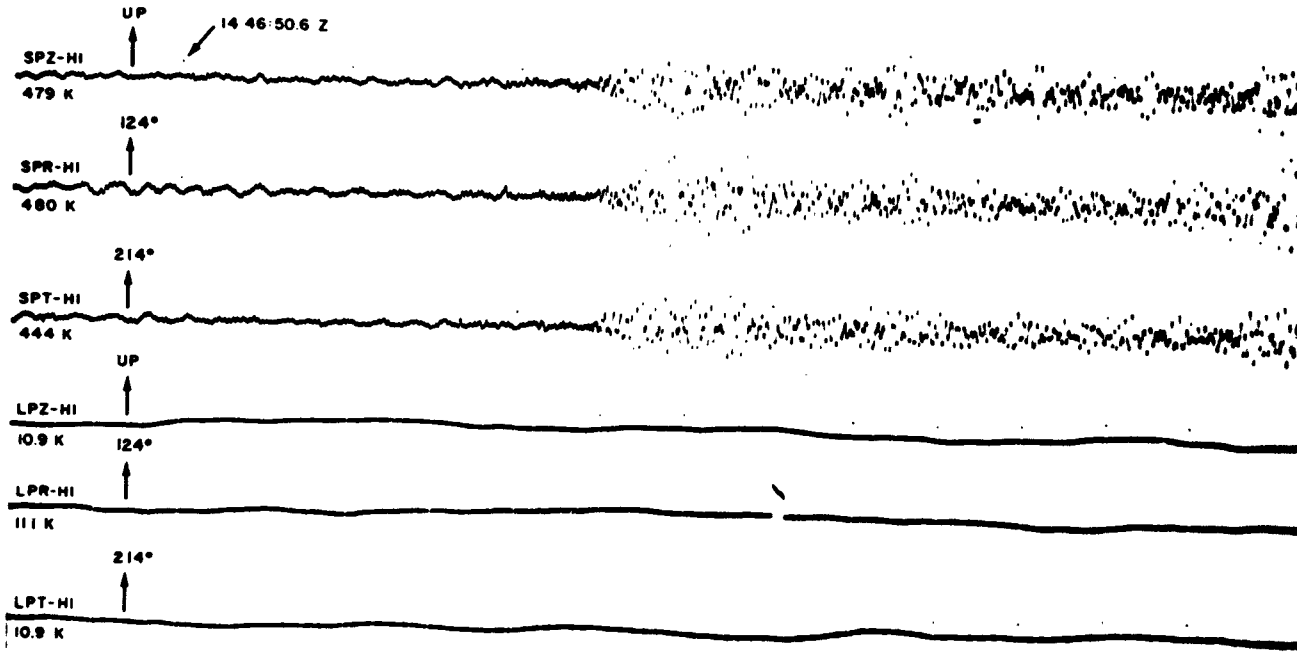
COLONA EARTHQUAKE

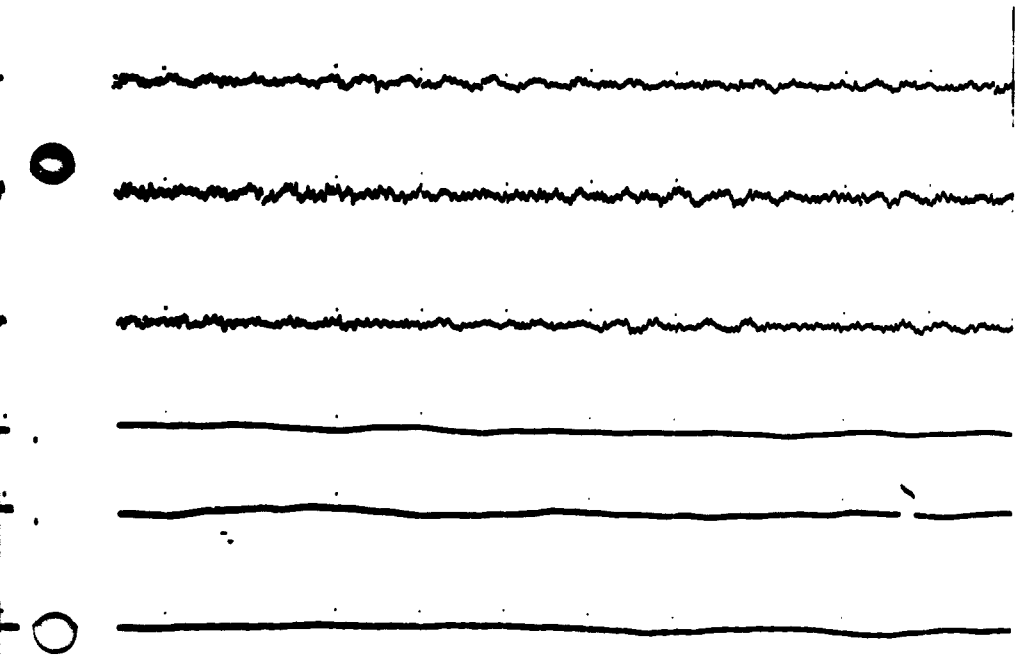
LC NM

Las Cruces, New Mexico

5 February 1962

Δ=650 km





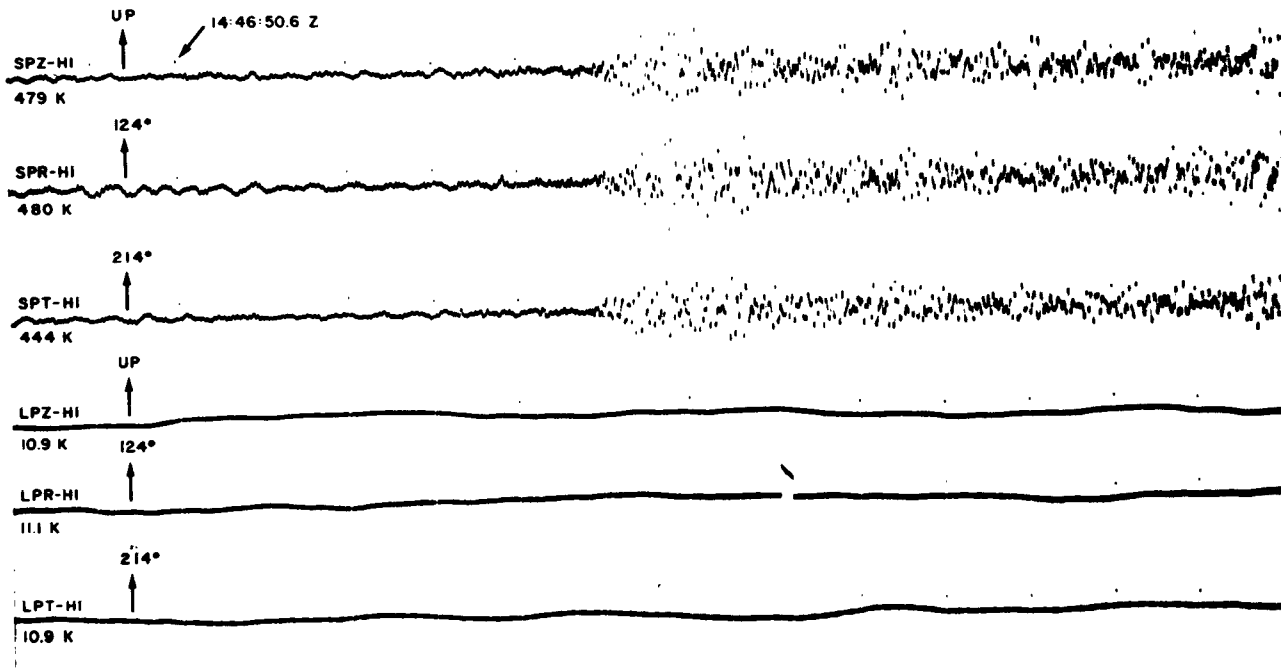
COLONA EARTHQUAKE

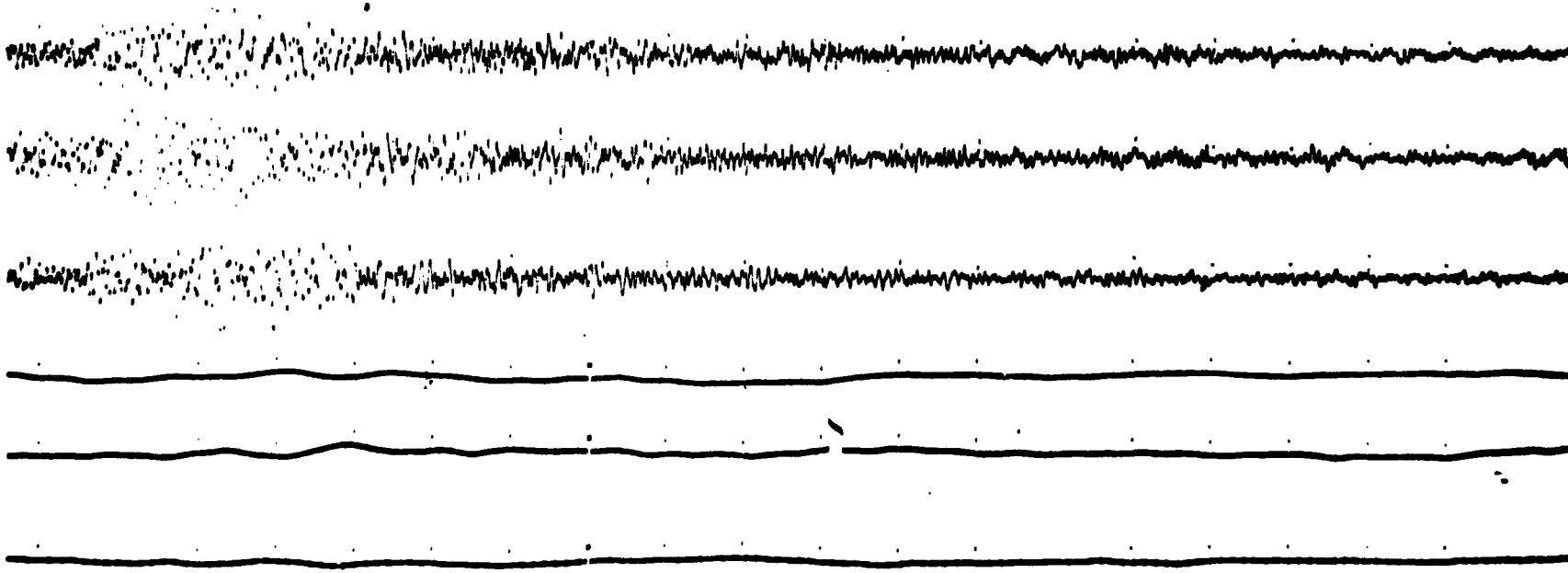
LC NM

Las Cruces, New Mexico

5 February 1962

Δ=650 km





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